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THE present number of the RAILROAD AND ENGINEERING JOURNAL contains the beginning of a series of articles under the general heading of "Contributions to Practical Railroad Information." The first of them, and some of the succeeding ones, will be on the subject of Chemistry Applied to Railroads, by C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad. These are contributed with the permission of Mr. Theodore N. Ely, Superintendent of Motive Power of that line, and, as their title implies, will give an account of the uses to which chemistry has been applied in the operation of a great system of railroads. The purpose of the articles will be to give plain accounts of knowledge gained by actual experience and practice on railroads, and show the advantages which have resulted from the application of the science of chemistry to the testing of materials, and to other departments of railroad operation.

It is intended that this first series of articles shall be succeeded by others on various subjects connected with railroad engineering, on which more or less definite information has been obtained on the Pennsylvania and other lines of railroad during the past 15 years.

THE Engineering Department of the Iowa State University has undertaken to make a series of tests of cements of various kinds. The tests and experiments will extend through the entire year, and will be conducted according to the methods suggested by the American Society of Civil Engineers. Great care will be exercised, and as the University is provided with the best apparatus for this purpose, the results cannot fail to be valuable. The testing machines and the whole outfit of the Cement Laboratory are new, having been recently furnished to the University by the firm of Riehle Brothers, of Philadelphia. Manufacturers can assist materially in these tests by furnishing samples of their cement, the freight charges on which will be paid by the University, but none will be omitted, as where samples are not furnished they will be purchased in the open market. The results of the tests will be published when they are completed.

IN an article given on another page, Dr. Roll, a distinguished Austrian authority, criticises somewhat severely the organization of the International Railroad Congress. Some of the defects which he mentions are, perhaps, inherent in the nature of such a body, but to those who have followed its proceedings since the first meeting, it must be apparent that others of his criticisms are not unjust. The conclusions reached by the Congress at the Paris meeting must, however, be of interest to railroad men everywhere, as the expressions of opinion given out by a body largely composed of men of long training and experience in their profession. That some of the conclusions are indefinite, and others evidently the result of a compromise, will not be disappointing to those who know anything of the nature and proceedings of similar associations here. The Congress attempts to cover a very extensive field and to dispose of a wide range of questions, the consideration of which, in this country, is divided up among a number of technical societies. It must be remembered also that it suffers from one trouble which equally affects our Conventions—the absence of any authority to enforce its decisions or to require their adoption by the several railroad managements, whether stated or private. Whatever its decisions may be, they are not binding, but only advisory in their nature, and the extent to which they are respected depends upon the individual managements.

One complaint made has a very familiar sound here—it is that the railroads do not, as a rule, take pains to answer the circulars of inquiry on different topics which are sent to them by the Executive Commission of the Congress. There are notable exceptions, it is true, but the neglect is general enough to make the results of the investigations conducted between the meetings far less satisfactory than they should be. On several points where it is desirable that experience all over Europe under widely varying conditions of climate, traffic, etc., should be collected, the results actually

given are from one or two countries—sometimes from one or two roads—only.

With all of these drawbacks, however, the results obtained so far—the Paris meeting was the third since the organization of the Congress—have been very good, and the papers and reports prepared have included a great deal which is valuable to railroad men everywhere.

The only delegate from the United States who took part in the last meeting of the Congress was Mr. Ely, of the Pennsylvania Railroad, who joined in the report on Question XIII.—On the Dead Weight of Trains.

THERE are to be next year some competitive trials between English and American locomotives, provided American builders respond to the invitation which has been sent them to take part in the Edinburgh Exposition. The managers of that Exposition have asked a number of the locomotive builders of the United States to send representative passenger and freight engines of American types for that purpose, and should they be sent, the trials will take place on some of the Scotch railroads. It is not very probable, however, that much will be done in this way, for while our American builders have no reason to fear the results of such a contest, the expense of sending a locomotive to Scotland will be very great, and the prospect of any material return very small. The same reasons which prevented any large representation of this department of our manufactures at Paris will operate still more strongly against a local exposition like that at Edinburgh.

FROM arrangements recently completed, which include the consolidation of two of the Swiss Railroad companies, and a contract made by them with several German banks, it appears probable that work will soon be begun upon the great Simplon Tunnel, which will be the fourth tunnel under the Alps, and the longest tunnel in the world. From the surveys for this tunnel, which were made some years ago, the length has been determined at 19,795 m. (12.30 miles), and in addition to this there will be a connection about 1¼ miles in length from the northern end of the tunnel to Brieg, where the connection with the Swiss railroads will be made. The grade in the tunnel will run both ways from the summit near the center, having a fall of 1:500 going northward to Brieg, and of 1:125 going southward to the Italian end at Iselle.

The cost of this tunnel is estimated by the engineers at a little less than 4,000 francs per running meter, which would bring it up to about $16,000,000. Adding to this the cost of the short line north of the tunnel, the interest on the capital employed during construction, and making allowance for unexpected difficulties which may be encountered, it is thought that about $18,000,000 will be required. A portion of this capital will be supplied by subsidies from some of the Swiss cantons, from the Italian Government and from the cities of Milan and Genoa; the remainder will be furnished by the Swiss companies. It is expected that between seven and eight years will be required for the excavation of the tunnel.

A REPORT has recently been made by the Commission of Engineers appointed to consider the plan for connecting the city of Paris with the sea by a ship canal. The report is strongly in favor of the work, and says that the engineering difficulties to be encountered are not great, while the advantages to be obtained will fully warrant the expenditure required, which is estimated at $40,000,000. The canal would be 180 km. (112 miles) long, and would have a depth of 6.2 m. (20.34 ft.). The material excavated could, it is said, be advantageously used in raising the levels of the lowlands adjoining the lower Seine.

THE Girard Hydraulic Railroad, which attracted so much attention at the Paris Exposition, is to have a practical trial in England under the direction of Sir Edward Watkin. An experimental line of two miles in length will be built near London, and a thorough test made of the invention under conditions as near those of practical working as possible.

FOR some time past there have been very contradictory advices in relation to the Chinese railroads. Nearly a year ago the proposed extension of the Tien-Tsin Line—the only railroad in China—was stopped after work had been actually begun upon it. In September last, a new start was taken, and it was stated that the construction of a very important trunk line, extending from Pekin across the country to Hankow, a distance of about 700 miles, was ordered, and the necessary surveys were begun. The latest news, however, announces that the party which is opposed to the introduction of railroads and other foreign inventions has succeeded in carrying its point, and that the building of this road had been indefinitely postponed. What the result will be it is impossible to say; but there is no doubt that the progressive party, headed by the Viceroy Li-Hung-Chang, will use every effort to secure the execution of the first decree and the building of the road. Any innovation in China has to encounter such an enormous opposition from the rooted political and social prejudices of the people that the introduction of railroads is no easy task.

FOR the year ending with September last the traffic of the Manhattan Elevated lines in New York shows a lower percentage of increase than for some years past, the figures being as follows, including all the lines, for four years:

	1885-86.	1886-87.	1887-88.	1888-89.
Passengers.....	115,109,591	158,963,232	171,529,789	179,497,433
Increase over previous year.	11,754,862	42,853,641	12,566,557	7,967,644
Per cent. of increase.....	11.4	37.2	7.9	4.6

The increase in 1886-87 was the largest in any one year since the opening of the roads, and was due to a variety of causes; it is not probable that such an extraordinary gain will be shown in one year hereafter, unless under exceptional circumstances—the holding of the International Exposition in the city, for instance.

It may be of interest to compare the traffic of the several lines for three years past, as is done in the following table, in which the first column under each year shows the number of passengers carried on each line, the second the percentage of the total number credited to that line:

	1886-87.		1887-88.		1888-89.	
Lines.	Number.	Pr. ct.	Number.	Pr. ct.	Number.	Pr. ct.
Ninth Ave....	16,650,707	10 5	17,814,411	10.4	18,131,368	10.1
Sixth Ave.....	45,204,992	28.3	53,115,965	31.0	58,329,410	32.5
Third Ave.....	66,575,454	41.9	68,308,460	39.8	69,924,730	39.0
Second Ave....	30,532,079	19.3	32,290,953	18.8	33,111,925	18.4
Total 158	963,232	100.0	171,529,789	100.0	179,497,433	100.0

Thus the percentage of the total traffic carried by the West-side lines—Sixth and Ninth avenues—for the three years respectively, has been 38.8, 41.4, and 42.6, while

that going over the East-side lines—Third and Second avenues—has been 61.2, 58.6, and 57.4. The East-side lines still continue to carry the larger number of passengers, and have not only held their own in actual numbers, but show a small and pretty steady gain; but the main increase has been on the West-side lines. This is not surprising to any one who has watched the growth of the city and has seen how much the tendency of population has been to the West side. This has been in a measure necessary, for the East side of the city was in great part built up years ago, and on the West side, up-town, were the only considerable tracts of land open for building. This is still the case, and a further development of traffic in that direction is to be expected.

ONE thing is evident to all who have any acquaintance with the city travel; the present lines have very nearly reached the limit of their capacity. They are already unable to accommodate the ordinary travel properly, in spite of careful and efficient management, and any considerable increase must cause trouble. No great addition to their capacity is possible, and the building of new lines of some kind is a necessity, if the city is to continue to grow. What they are to be is, at present, very uncertain; there are plenty of projects, but very little prospect that any of them can overcome the opposition of rival interests.

THE International Marine Conference has continued its sessions in Washington during the month, and the members have worked hard at the long and important programme of subjects submitted for their discussion. At the present writing the work has not yet been concluded, but a substantial agreement has been reached on the rules establishing a general code of signals and the rules of the road at sea. The work has so far been well done and will have excellent results. It will take some time to secure general approval of the action of the Conference, but the probability is that it will be accepted in the end by all the leading maritime nations.

THE new cruiser *Baltimore* passed through her second trial very successfully, proving herself, as on the first trial, to be a very fast boat. The full official details of the trial have not been published as yet, but it is stated that the average speed for the four hours' run was 20.1 knots per hour, or somewhat in excess of the average of the former trial. The *Baltimore* has thus proved herself to be one of the fastest war-vessels in the world. There is no doubt that she will be accepted, and the probability is that the official figures will show that the full power required by the contract has been developed.

PLANS have been completed and bids called for for the construction of four more vessels, which have been authorized by Congress. These are the Thomas submerging cruiser; two 1,000-ton cruisers—Nos. 11 and 12—and the practice cruiser for the Naval Academy. The Thomas cruiser is to be a vessel of the *Monitor* type. It was described and illustrated in the JOURNAL for February and March last.

The two 1,000-ton cruisers are to be small vessels carrying a powerful armament for their size. The general dimensions are: Length, 190 ft.; breadth, 32 ft.; mean draft, 12 ft.; displacement, 1,050 tons. They are to carry two masts, with fore-and-aft rig, and will be able to make a considerable spread of canvas. The engines will be of the triple-expansion type, capable of working up to 1,600 H.P., and the maximum speed is to be 14 knots an hour. These ships will carry a main battery of eight 4-in. rapid-fire guns and a secondary battery of four revolving cannon, one small rapid-fire and one Gatling gun.

The practice cruiser has been designed with the idea of including complete facilities for practical instruction in seamanship, steam engineering, ordnance, and torpedo service. Its dimensions will be as follows: Length, 180 ft.; breadth, 32 ft.; mean draft, 11½ ft.; displacement, 835 tons. The vessel will carry three masts. The engines will be capable of working up to 1,300 H.P., and the maximum speed will be about 13 knots. At a low speed—eight knots—the ship will have a cruising range of 3,850 knots, with her normal coal supply. The armament will consist of four 4-in. rapid-fire guns as a main battery, five small rapid-fire guns, one revolving cannon, and one Gatling gun as a secondary battery, and it will also be provided with torpedo equipment.

A THANKSGIVING SERMON ON ETHICS AND RAILROAD SUPPLIES: BY A LAYMAN.

ON Thanksgiving Day it is not unusual for preachers to feel that the restraints of their sacred calling are temporarily loosened, and that they are then at liberty to discuss some secular subject in their annual sermons. It is, perhaps, quite as natural that such occasions should lead persons whose lives are devoted to secularity to serious reflections, as it is that those whose duty it is to be solemn should then feel buoyant. If on the day set apart for cultivating and expressing the feeling of gratitude clergymen wander from their own special precincts—in which no one is authorized to speak but themselves—into other fields, where only editors assume infallibility, the former can hardly demur if at the same time one of us should assume the privilege of discussing moral and ethical subjects, and, as it were, "exchange pulpits" with them.

Traditional gossip also bears witness to the practice among the clergy of periodically inverting their barrel of old sermons. Frankly be it admitted, then, that in this, too, we are imitating the example of our clerical brethren. We have turned the receptacle of old editorials upside down, and, lo and behold! among them is a sermon which was preached years ago, from another pulpit, it is true, but, doubtless its precepts were instilled into some of those who will form part of the congregation at our imaginary service this year. Be it understood, then, that this is the same old sermon, but thoroughly revised to "suit the times," and with a new text, which is from Job 17 : 9: *The righteous also shall hold on his way, and he that hath clean hands shall be stronger and stronger.*

Following the method of the preachers, we will begin by ignoring our text entirely, and commence with an interrogative:

Firstly. What is Ethics? Going to the dictionary for an answer, we find that it tells us, among other things, that it is the "science of human duty," and "rules of practice in respect to a single class of human actions." Going back, then, to the subject of our sermon, and we may para-

phrase it into Rules of Practice in Respect to the Purchase of Railroad Supplies. This amplification of our subject leads us to

Secondly. What are the rules of practice in respect to the purchase of railroad supplies? Much might be said or written on this branch of our subject. A conscientious novice who undertakes to sell materials or equipment to railroad companies will find that there is a great deal to be learned of human nature in that department of human action. A little experience will very soon lead him, like David—or whoever wrote Psalm 116—to say in his haste, "All men are liars." This, as the author of the quotation intimated, will be a hasty conclusion, and to some extent untrue. The natural supposition of a conscientious man would be that those intrusted with the duty of procuring supplies for a railroad would be concerned, first of all, and entirely, in getting such articles as would be of the greatest service to the companies whose interests they represent. Now, while this is so in *most* cases, there are many in which quite different motives have an influence in the selection of what is bought and supplied to the companies.

Now, what are these motives? To avoid misapprehension, it will be well to begin by saying that on many railroads those intrusted with the duty of selecting and determining where and what equipment and supplies shall be bought, are as scrupulous, as conscientious, as honorable, as just, as sagacious, and intelligent as any class of business men in the community. On other roads the condition of things is somewhat otherwise. Personal favoritism and the cupidity of those who are intrusted with this duty influence their decisions and actions to a greater or lesser extent. To speak plainly, it is generally believed that on many roads the selection and purchase of materials is influenced by some form of bribery. This brings us to

Thirdly. What is bribery? It has been defined "as the administration of a consideration or reward, that it *may be* a motive in the performance of functions for which the proper motive ought to be a conscientious sense of duty."

There is an impression in the minds of some persons that bribery is a modern vice. The Scriptures give abundant evidence that it existed in ancient times, and that its influence was almost as well understood in those days as it is now. Thus in Proverbs we read:

> The king by judgment establisheth the land; but he that receiveth gifts overthroweth it.—*Proverbs* 29 : 4.

When Samuel in his old age challenges a rigid scrutiny of his conduct, he says:

> I am old and gray-headed; and, behold, my sons are with you: and I have walked before you from my childhood unto this day. Behold, here I am: witness against me, . . . whom have I defrauded, whom have I oppressed? or of whose hand have I received any bribe to blind mine eyes therewith?—1 *Samuel* 12 : 1–3.

Again, it is said:

> And it came to pass, when Samuel was old, that he made his sons judges in Israel. . . . And his sons walked not in his ways, but turned aside after lucre, and took bribes, and perverted judgment.—1 *Samuel* 8 : 1–3.

And Amos, when denouncing the condition of the Israelites under Jeroboam, says:

> Ye have built houses of hewn stone, but ye shall not dwell in them; ye have planted pleasant vineyards, but ye shall not drink wine of them. For I know your manifold transgressions and your mighty sins: they afflict the just, they take a *bribe* (or *ransom*), and they turn aside the poor in the gate from their right.—*Amos* 5 : 11, 12.

The reference to those who "have built houses of hewn stone" sounds as though Amos had some modern railroad men in mind.

The condemnation of the author of Psalm 31 is also emphatic. He says:

> Judge me, O LORD; for I have walked in mine integrity: . . . Gather not my soul with sinners, nor my life with bloody men; in whose hands is mischief, and their right hand is full of bribes.—*Psalms* 26 : 1–10.

Neither is it possible to mistake Job's opinion of bribery. There are railroad men who would probably do well to either reform some of their practices or else not read what Job says, or perhaps better still, read and then reform. He exclaims:

> For the congregation of hypocrites shall be desolate, and fire shall consume the tabernacles of bribery. They conceive mischief, and bring forth vanity, and their belly prepareth deceit.—*Job* 15 : 34, 35.

The case of Lord Bacon stands out most prominently as an example in history, as the one which made the acceptance of bribes by judges infamous. He was accused, and finally confessed to receiving bribes while acting as Lord Chancellor on 28 different occasions. He palliated nearly all of those by the fact that the considerations were received *after* his decisions had been made, and affirmed that he never "had bribe or reward in his eye or thought when he pronounced any sentence or order," and it is said by one of his biographers that "so far as any of these cases can be traced, his decisions, often being in conjunction with some other official, are to all appearances thoroughly just."

Notwithstanding these extenuating circumstances, he was found guilty, and sentenced "to undergo a fine and ransom of £40,000; that he should be imprisoned in the tower during the King's pleasure; that he should be forever incapable of any office, place, or employment in the State or commonwealth; that he should never sit in parliament, or come within the verge of the court." This decision, his historian * says, "had a great constitutional value; it inflicted upon an abuse which had been heretofore tolerated a punishment which made it thereafter infamous. All questionable transactions between judges and suitors were from that day at an end in England."

Bacon made the plea that his intentions had always been pure, and had never been affected by the presents he received. His justification has been set aside by modern critics, not on the ground that the evidence demonstrates its falsity, but because it is inconceivable or unnatural that any man should receive a present from another, and not suffer his judgment to be swayed thereby.† This suggests

Fourthly. Why is it wrong to take bribes, and when is it culpable to receive gifts?

A great many persons who accept bribes excuse themselves, as Bacon did, with the plea that their intentions and judgments are not swayed by the presents they receive. It may be inferred that such persons have never analyzed very scrupulously the "processes of voluntary action, as well as the emotional states that precede and prompt to it," and do not realize how delicate that quality of disposition is which must be exercised when we sit in judgment

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* See "An Account of the Life and Times of Francis Bacon," extracted from the edition of his occasional writings, by James Spedding. Houghton, Osgood & Company, Boston.

† See article on Francis Bacon in the Encyclopædia Britannica.

on matters where it is difficult to discern right from wrong, or truth from error. As a writer on ethics says, "It is held that a certain state of the agent's mind, a certain quality of disposition, motive, intention, or purpose is essential to the perfect moral goodness of an action." Now, what shall be thought of a person who occupies a position of responsibility, and to whom is confided a trust, and who is paid to be loyal to the interests of those who employ him, and who yet allows the sordid motive of private gain to be interposed between him and his duty. If the strongest trees incline in the direction of prevailing winds, how much more likely that a plant as delicate as the human conscience will yield under the influence of a greed for gain. Righteousness, or the quality of being right, just, equitable, and impartial, will wither in the atmosphere of human covetousness. He who accepts a bribe poisons the very motives of rectitude, and admits the virus of iniquity into the sacred temple of his own honor.

The old biblical writers understood this. Solomon said that a king who received gifts "overthroweth the land." With equal force it might be written to-day that a manager of a railroad who receives gifts "overthroweth it," and a good many of them have done so. Samuel protested that *his eyes had not been blinded* by receiving any bribes, and it is said that his sons who succeeded him "turned aside after lucre, and took bribes and perverted judgment." It is as true to-day as it was thousands of years ago, that the effect of bribes now is *to blind men's eyes* and *pervert judgment*, and there are railroad men to-day who, if not blinded, have certainly been made mentally and morally cross-eyed by receiving gifts.

David speaks of these as "bloody men, in whose hands is mischief." It could be said to-day of a certain class of men on railroads and elsewhere whose "right hands are full of bribes," that they are "bloody men in whose hands is mischief." It is often the duty of such men to be the judges of the efficiency of certain appliances for the safety of those who travel, and more than all, those who are employed on railroads. No condemnation can be too severe on men in such positions whose judgments are perverted by turning aside after lucre. Think of the responsibility of a person who has deliberately defiled the highest faculty of a human being, that of free will, and it may be has thereby caused human life to be sacrificed and been responsible for untold suffering.

The insidious way in which bribery is practised often makes it difficult for those who have not much mental acuteness to recognize the enormity of it. Playing cards and letting the person to be bought win is an old practice. Another is to begin by giving small gifts, and gradually increasing the value of the bribes. The receiver does not discover until it is too late, and he is in the power of the giver, that he is on dangerous ground. An instance is related of a manufacturer who was obliged to send an agent to erect and put his machines to work at an expense of $100. The Master Mechanic was informed that it was his duty to erect and put the machines to work, and that if he would do so the manufacturer would thereby be saved the expense of sending an agent to do the work; and that if he would attend to the business for them, that they would pay him the $100 instead of paying it to an agent. This all looks very fair, and unless a person in the position of the Master Mechanic has considerable capacity to discover nice moral distinctions, he would not see wherein it was wrong for him to receive the money. It was, nevertheless, as much a bribe as though it were not disguised so ingeniously, because it was "the administration of a reward that it might be a motive in the performance of functions for which the proper motive ought to be a conscientious sense of duty."

To describe the various methods which are adopted in order to make it appear that the receiving of gifts is *not* bribery, would take a long article to describe. They are administered under the guise of disinterested friendship. The wives and daughters, and the sisters, the cousins and the aunts of the persons to be influenced are sometimes the recipients of the benefits. The sacrificial Thanksgiving turkey has no doubt done service in this capacity full many a time and oft.

The evil is not confined to any class. Charges of such infidelity are made against persons in the highest as well as the lowest positions. Our own craft is not blameless. The influence of free passes in blinding editorial eyes and perverting journalistic judgment would furnish material for a whole sermon.

Another insidious form that bribery takes is that of advertising schemes like maps, catalogues, etc., which are issued by and are a source of profit to the subordinate officers of railroads. They send letters to and personally solicit advertisements from those who sell material or equipment to their companies. The manufacturers or dealers are afraid to refuse, for fear of losing the business, which in many cases the solicitors can influence. This is worse than a bribe, because it is *soliciting* a consideration, which may be a motive in the performance of functions for which the proper motive ought to be a conscientious sense of duty. It is, in fact, a form of extortion. If persons who can influence or control the purchase of railroad supplies palliate such practices, as Bacon did, by saying that they have not the profit of advertisements in their eye or thought when the purchase of supplies is under consideration, most persons will feel inclined to put their tongues in their cheeks and pass by on the other side. The higher authorities on railroads should peremptorily suppress this practice, which requires a harsh name to designate it properly.

Another incentive to unfaithfulness to the trust which most railroad officers hold is the owning stock or holding interests in companies or firms engaged in the manufacture or the sale of equipment, supplies, or material, on which such officers must sit in judgment. In cases of this kind they receive a reward from the profits of such companies or firms, which "may be a motive in the performance of functions for which the proper motive ought to be a conscientious sense of duty," and it thus comes within the definition of bribery, and ethically has the same character. There is no doubt that many railroad officers, including directors, have such interests, and receive such rewards, and think they do no wrong. Another sermon would be needed to discuss this fully. The topic is commended to the consideration of our clerical brethren whose vocation it is to awaken the consciences of sinners.

There remains for consideration on the present occasion only

Fifthly and lastly. What is the cure for bribery in railroads?

As it is largely a moral question, of course the evil to a very great extent must be overcome by moral agencies. At present such practices are tolerated, condoned, and are condemned, as it were, in a whisper. Open condemna-

tion of the practice is the purpose of this sermon. Let every person with a clear conscience express his or her opinion freely on the subject.

In Bacon's time the receiving of gifts and bribes by judges was tolerated. His trial and sentence, owing to the eminent position which he held, made the abuse thereafter infamous. Doubtless a similar result would now follow a like cause. Let one or more railroad men of greater or lesser prominence be tried, convicted, and disgraced, and it will make bribery on American railroads infamous, as it did in English courts more than 250 years ago.

In conclusion, we will quote once more the words of our text:

THE RIGHTEOUS ALSO SHALL HOLD ON HIS WAY, AND HE THAT HATH CLEAN HANDS SHALL BE STRONGER AND STRONGER.

NEW PUBLICATIONS.

CHEMICAL TECHNOLOGY; OR, CHEMISTRY IN ITS APPLICATIONS TO ARTS AND MANUFACTURES: EDITED BY CHARLES EDWARD GROVE AND WILLIAM THORP. VOLUME I: FUEL AND ITS APPLICATIONS: BY E. J. MILLS AND F. J. ROWAN. Philadelphia; P. Blakiston, Son & Company, 1012 Walnut Street.

It is impossible—and would, indeed, be unjust to the authors—to attempt an exhaustive review of a volume of this kind on short notice. Its value can only be learned after a period of use as a book of reference, and therefore any extended or critical notice must be postponed until a later date. It is sufficient to say at present that this volume is the first of a new edition based upon the Mechanical Technology of Richardson and Watts, greatly enlarged, rewritten, and brought up to the present date.

The first volume, on Fuel, is naturally one of the most important and practical in its direct applications. It contains chapters on Wood; on Peat; on Charcoal; on Coal; on Coke; on Artificial Fuel; on Liquid Fuel; on Gaseous Fuels; on the Different Applications of Fuel; on Ovens; on Furnaces, etc., etc. Great pains have been taken to collect information from all possible sources and to include the results not only of experiments, but of practical working in a number of different directions. The general plan and scope may, perhaps, best be shown by the following extract from the Preface:

> In fact, the progress in this department has been such that this volume, although founded on the earlier one, is really a new work, and this remark will necessarily apply also to the volumes on Lighting, etc., which will follow. Where possible, historical matter from the old edition has been retained, especially on account of its great value in the case of processes or appliances which are capable of being made the subjects of patents. It is not too much to say that many patents owe their existence to ignorance concerning what has been done in the matters of which they treat; and manufacturers would often find historical information of great use if it were available without laborious searching through Patent Office records.
>
> The subjects of the manufacture of gas for illumination, methods of lighting by oil and gas, the manufacture of candles, the distillation of coal, shale, wood, and peat, with the secondary products obtained therefrom, miners' safety-lamps, and other lamps used for lighting, have been excluded from this volume, which is consequently restricted to the consideration of Fuel and its Applications.
>
> Where possible the duty obtained from the fuel in furnaces has been quoted, and general rules have been given by which the duty of any stated furnace or heating appliance may be estimated.

The book is very fully illustrated, as, indeed, the nature of the subject requires, and includes a large number of tables giving fuel statistics, analyses of different fuels, and comparative results. It has, what every book of the kind should, but does not always have, a very full index.

THE AMERICAN RAILWAY: ITS CONSTRUCTION, DEVELOPMENT, MANAGEMENT, AND RESOURCES: BY VARIOUS AUTHORS. New York; Charles Scribner's Sons (price, $6).

The railroad articles, the publication of which was begun in *Scribner's Magazine* a year and a half ago, have developed into this handsome volume, which includes the various articles published in the *Magazine*, which have been revised by the authors, with a brief introduction written by Judge Thomas M. Cooley, Chairman of the Interstate Commerce Commission, and a supplement of a statistical character written by Fletcher W. Hewes. Probably most of our readers have seen the articles in their original form. It is sufficient to say that they include accounts of the construction of the railroad and its rolling stock; of engineering feats; of safety appliances; of the methods of conducting passenger and freight business; of the details of railroad management, and of the every-day life of railroad men, with chapters on the economic and social relations of the railroad, on the relation of the railroad to its employés, and on railroad mail service, all written by experts in the various departments. Judge Cooley's introduction is a brief but clear exposition of the present lack of system and co-operation among the different roads in the important matter of rates and through business. The statistical supplement gives an interesting collection of maps and tables, showing the geographical distribution and business of the railroads of the country.

The book is not an exhaustive or scientific treatise on railroads, but it contains a great body of information presented in a popular form, and should be of interest to almost all reading people. It is profusely illustrated and the mechanical execution is excellent, making it a very attractive volume of over 450 pages.

EVERYBODY'S HANDBOOK OF ELECTRICITY. WITH GLOSSARY OF ELECTRICAL TERMS AND TABLES FOR INCANDESCENT WIRING: BY EDWARD TREVERT. Boston, Mass.; Damrell & Upham; Lynn, Mass.; The Lynn Book Agency (price 25 cents).

Electricity is a pretty extensive subject to be treated in a book of 120 pages; but this does not make any pretense of completeness, the Author having only attempted to give an outline of the progress made to date with electric lighting, motors, etc., and a popular explanation of the methods usually adopted in generating electricity, the construction of dynamos, batteries, etc. Considering it only as what it claims to be, it is worth attention, and will be of service to the large class who have not time to give to a special study of the subject, but wish to form a general idea of what has been done, and of how it has been done. Perhaps the general explanations have been somewhat too much condensed, and might have been clearer had more space been given to them and less to descriptions of special appliances; and some improvement might have been made in the illustrations. Not too much is to be expected in a book of this kind, however; and it may be considered a very convenient handbook for those who are interested in the

subject—and there are few intelligent people now who do not want to know something about it.

BOOKS RECEIVED.

THE STEAM-ENGINE AND THE INDICATOR: THEIR ORIGIN AND PROGRESSIVE DEVELOPMENT; INCLUDING THE MOST RECENT EXAMPLES OF STEAM AND GAS MOTORS; WITH THE INDICATOR, ITS PRINCIPLES, ITS UTILITY, AND ITS APPLICATION: BY WILLIAM BARNET LE VAN. Philadelphia; Henry Carey Baird & Company, 810 Walnut Street (470 pages, 205 illustrations; price $4).

TEST OF STRONG LOCOMOTIVE NO. 1, *A. G. Darwin*, AND ENGINES 41, 136, AND 31 OF THE NEW YORK, LAKE ERIE & WESTERN RAILROAD. New York; issued by the Strong Locomotive Company.

THE MAKING OF A GREAT MAGAZINE. New York; Harper & Brothers.

THE DEVELOPMENT OF THE PHILOSOPHY OF THE STEAM ENGINE. AN HISTORICAL SKETCH: BY ROBERT H. THURSTON. New York; John Wiley & Sons, No. 15 Astor Place (price, 75 cents).

ELEMENTARY BUILDING CONSTRUCTION AND DRAWING: BY EDWARD J. BURRELL. London and New York; Longmans, Green & Company.

STEAM: BY WILLIAM RIPPER. London and New York; Longmans, Green & Company. This is a treatise on Steam and Its Economical Use, which will receive more extended notice hereafter.

UNITED STATES GEOLOGICAL SURVEY, MONOGRAPH NO. XIV. FOSSIL FISHES AND FOSSIL PLANTS OF THE TRIASSIC ROCKS OF NEW JERSEY AND THE CONNECTICUT VALLEY: BY JOHN S. NEWBERRY. Washington; Government Printing Office.

UNITED STATES GEOLOGICAL SURVEY, MONOGRAPH NO. XIII, WITH ATLAS. GEOLOGY OF THE QUICKSILVER DEPOSITS OF THE PACIFIC SLOPE: BY GEORGE F. BECKER. Washington; Government Printing Office. The Atlas accompanying this Monograph is a beautiful specimen of map-making, as, indeed, are all the maps of the Geological Survey.

BULLETIN OF THE UNITED STATES GEOLOGICAL SURVEY, NOS. 48–53. Washington; Government Printing Office. Each of these numbers treats of a different subject, as follows: No. 48. Form and Position of the Sea Level. No. 49. Latitudes and Longitudes of Certain Points in Missouri, Kansas, and New Mexico. No. 50. Formulas and Tables to Facilitate the Construction and Use of Maps. No. 51. Invertebrate Fossils from the Pacific Coast. No. 52. Subaërial Decay of Rocks and Origin of the Red Color of Certain Formations. No. 53. Geology of Nantucket. All are fully illustrated.

AMERICAN INSTITUTE OF ARCHITECTS, TWENTY-SECOND ANNUAL CONVENTION, HELD IN BUFFALO, OCTOBER 17–19, 1889: A. J. BLOOR, EDITOR. New York; issued by the Institute.

TRANSACTIONS OF THE INSTITUTION OF CIVIL ENGINEERS OF IRELAND, FOR THE 53D SESSION, TO JUNE, 1888: VOLUME XIX. Dublin, Ireland; published for the Institution.

REPORTS OF THE CONSULS OF THE UNITED STATES; NO. 108, SEPTEMBER, 1889: PREPARED BY THE BUREAU OF STATISTICS, DEPARTMENT OF STATE. Washington; Government Printing Office.

HIGHWAY IMPROVEMENT: BY COLONEL ALBERT A. POPE. This is a reprint of an excellent address delivered before the Carriage-Builders' National Association at its meeting in Syracuse, N. Y., in October, by Colonel Pope, of Boston.

THE WHISTLE SIGNAL: A PLEA FOR THE MORE SAFE MANAGEMENT OF RAILROADS: BY ROBERT BARCLAY, A.M., M.D. St. Louis, Mo.; published by the Author.

METHODS OF LAYING CONCRETE UNDER WATER. New York; issued by John G. Goodridge, Jr.

THE WESTINGHOUSE—EDISON CASE. New York; published by the Edison Electric Light Company. This is a pamphlet containing the full text of Judge Bradley's opinion in the case of the Consolidated Electric Light Company against the McKeesport Light Company in the United States Circuit Court in Pittsburgh.

STEAM PLANTS FOR DRIVING DYNAMOS IN ELECTRIC LIGHTING, RAILROAD, AND POWER STATIONS: CATALOGUE AND DESCRIPTION. St. Louis; issued by the Pond Engineering Company. This is a new and enlarged edition of the Pond Company's pamphlet on this subject, in which the benefit of a large experience in furnishing and erecting such plants is shown.

THE TABOR STEAM ENGINE INDICATOR: CATALOGUE AND DESCRIPTION. The Ashcroft Manufacturing Company; New York and Bridgeport, Conn.

YORK MANUFACTURING COMPANY: CATALOGUE OF STEAM ENGINES, BOILERS, ETC. York, Pa.; issued by the Company.

THE JARMAN ICE AND REFRIGERATING MACHINERY: CATALOGUE AND DESCRIPTION. York, Pa.; issued by the York Manufacturing Company.

TAYLOR MANUFACTURING COMPANY: CATALOGUE OF HIGH-SPEED, AUTOMATIC CUT-OFF ENGINES. Philadelphia and Chambersburg, Pa.; issued by the Company.

ENGINEERING AND OTHER INSTRUMENTS OF PRECISION: THE AMERICAN TRANSIT INSTRUMENT. Philadelphia; Young & Sons, Manufacturers.

THE JUDSON PNEUMATIC SYSTEM FOR STREET RAILROADS: ILLUSTRATED DESCRIPTION. New York; issued by the Judson Pneumatic Street Railway Company, No. 45 Broadway.

STEAM BOILERS PRACTICALLY CONSIDERED: FOURTH EDITION, 1889. St. Louis, Chicago, Kansas City, and Omaha; issued by the Pond Engineering Company. This is a new edition of a very useful and practical treatise published by the Pond Engineering Company.

ABOUT BOOKS AND PERIODICALS.

IN the JOURNAL of the Military Service Institution for November, Lieutenant H. L. Hawthorne writes of an Interoceanic Canal between the Atlantic and Pacific chiefly in its strategic relations. The Use of Railroads in War, by Lieutenant Carl Reichmann, is a careful paper, and includes some account of the services rendered during our own great war by railroad men, who have been rather neglected by most war writers.

In Sensitive Flames and Sound Shadows, in the POPULAR SCIENCE MONTHLY for November, Professor Stevens gives an example of careful study and analysis of a physical question. The Art of Cooking, by Edward Atkinson, and a note on Science in Domestic Economy will be of value to all of us who have to do with household arrangements—and who has not?

Poverty and Charity in San Francisco, is an interesting study of industrial and economic conditions in California in the OVERLAND MONTHLY for November. This magazine ought to be read by every one who wants to keep up with current opinion among our brethren on the Pacific Coast; and it contains much matter that is of interest everywhere.

The account of the Mexican Army in HARPER'S MAGAZINE

for November will be appreciated by military readers. In the same number Señor Becerra gives a condensed account of the Republic of Colombia, in which he shows the extent of the resources of that country, and the urgent need of railroads, steamboats, and other means of communication for their development.

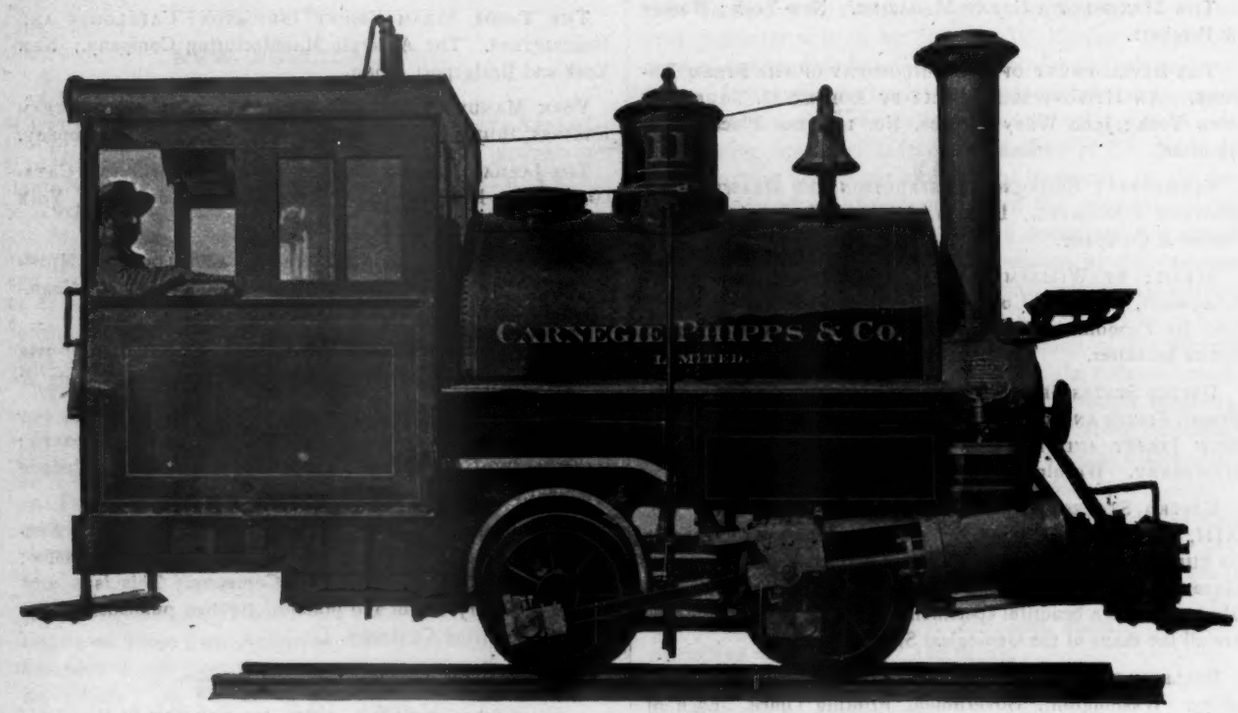
One of the most carefully studied articles in the November SCRIBNER'S is on the Effect on American Commerce of an Anglo-Continental War, by J. Russell Soley, U.S.N. The electrical article for the month is medical rather than mechanical, treating of the Effect of Electricity on the Human Body.

The articles on the Portuguese in the Track of Columbus are concluded in the last quarterly number of the BULLETIN of the American Geographical Society. The Geographical Notes in this number include a very interesting one on the Deep Troughs of the Oceanic Depressions—that is, the deep valleys which hydrographic surveys have shown to exist under the ocean.

A LIGHT SWITCHING LOCOMOTIVE.

THE accompanying illustration shows a four-wheel switching locomotive built by H. K. Porter & Company in Pittsburgh, for Carnegie, Phipps & Company, and used at the Homestead Steel Works of that firm for hauling ingots and other heavy material. The engine is of 30-in. gauge, and weighs in working order 27,500 lbs. The driving-wheels are 28 in. in diameter, and as some of the curves in the shop tracks are very sharp, the wheel-base in this engine was made only 4 ft. Some of the curves over which the engine is in daily use are only 40 ft. radius; and it may be mentioned here that smaller engines built by the same firm are in use over curves of only 16½ ft. radius. The journals on the driving-axles are $4\frac{1}{16}$ in. in diameter and 4¾ in. long.

The boiler is of the ordinary type, and is 31¾ in. in diameter of barrel; it has 66 tubes 1¾ in. in diameter, and 6 ft. 5 in. in length. The fire-box is 36 in. long inside, 16½ in. wide at the bottom, and 25 in. at the top, and is 40 in. in depth. The grate area is 4½ sq. ft. The chimney is 9⅞ in. inside diameter.



FOUR-WHEELED SWITCHING LOCOMOTIVE.

BUILT BY H. K. PORTER & COMPANY, PITTSBURGH, PA.

The cylinders of this engine are 10 in. in diameter and 14-in. stroke. The steam ports are ⅞ × 7⅝ in. in size and the exhaust ports 1¼ × 7⅝ in. The eccentrics have 2⅝-in. throw. The valves have $\frac{5}{16}$-in. outside lap, and their greatest travel is 2⅛ in. The exhaust nozzles are double, and are 1¾ in. and 2 in. in diameter.

Owing to the small size of the wheels, the engine looks somewhat low. The center of the boiler is 3 ft. 9 in. above the rails, and the total height from the rail to the top of the chimney is 9 ft. 8 in. As will be seen from the engraving, water is carried in a saddle-tank placed over the boiler, and having a carrying capacity of 500 gallons.

A number of engines of this pattern are in use at the same works and in the same service, and Porter & Company are now building some other locomotives of the same gauge to be used for hauling fluid metal in cars built specially for the purpose. They are also building a very small locomotive to be used for hauling ingots and blooms through the rail mill at the Edgar Thomson Steel Works, which is of the same general type as the one shown herewith.

The November CENTURY continues Mr. Kennan's account of the mining regions of Eastern Siberia. A short note and an energetic letter on International Copyright are worth reading, and there is a letter on the Use of Oil to Still the Waves. The purely literary part of the magazine need hardly be referred to here, except to say that it is well maintained, as usual.

Among other interesting articles in the MAGAZINE OF AMERICAN HISTORY for November is one on the First Iron Works in America, some notes from which will be found on another page.

The London ELECTRICIAN will continue next year the publication of its *Electrical Trades Directory and Handbook*; the issue for 1890 will be the eighth yearly number of this work. It is intended to include the names of electrical engineers and manufacturers in other countries as well as in England, and the publishers have taken considerable pains to make the list as complete as possible. It is the only publication of the kind, we believe, and ought to be a very useful one for all interested in electrical matters.

ON STRESSES PRODUCED BY SUDDENLY APPLIED FORCES AND SHOCKS.

BY MANSFIELD MERRIMAN.

WE are all familiar with the theorem that a force suddenly applied to a bar or beam produces double the stress caused by the same force when gradually applied. It is, indeed, the basis of some of the practical rules for proportioning the members in bridge structures and in machines. In this article I purpose to examine the mechanical grounds upon which this theorem rests, to show the distinction between a "suddenly applied force" and a "shock," and to compare the stresses produced by shocks with those that occur under static loads.

Let a bar be subject to a static force P acting in the direction of its length as a force of tension. Then the stress in the bar is also P, and this has produced a small elongation in its length. If the elastic limit of the material is not exceeded, the bar will spring back to its original length on the removal of the force.

If this force P be applied to the bar gradually by small increments, so that the force slowly increases from 0 up to the amount P, the stress in the bar increases in like manner, and if the elastic limit is not exceeded the elongation e is given by the well-known formula,

$$e = \frac{P l}{A E}$$

in which l is the length of the bar, A the area of its cross-section, and E the coefficient of elasticity of the material.

Now suppose the force P to be applied very suddenly to the end of the bar, as would be the case if a weight P were brought upon it by a quick shock. Then the stress in the bar increases from 0 up to an amount which is greater than P, and the elongation increases from 0 up to an amount which is greater than e. A series of oscillations now takes place, until finally the end of the bar comes to rest with the static elongation e and the stress in it is P. For instance, suppose a common spring balance whose spring elongates 1 in. under a steady load of 4 lbs.; and let a weight of 4 lbs. be dropped into the scale-pan from a height of 2 ft. Then it will be seen that the spring elongates about 8 in., thus, for an instant registering a tension of 32 lbs., but the pan immediately ascends until after a few oscillations the pointer comes to rest at the position which registers 4 lbs. This experiment may be easily tried by any one, but in order that the above result may be closely obtained, it is necessary that the scale-pan should be small and be rigidly attached to the spring, so that the work of the falling weight may not be dissipated in heat.

This illustration shows that the maximum stress due to a suddenly applied force or shock is but of momentary duration. Nevertheless, all experience teaches that this should be the stress considered in proportioning the bar, and that it should never be as high as the elastic limit of the material.

Let P be the weight which is dropped from a height h upon the end of the bar, or upon the scale-pan of the spring balance, and let y be the maximum elongation which is produced. The work performed by the falling weight then is

$$k = P(h + y),$$

and this must equal the internal work of the resisting molecular stresses. The stress in the bar which is at first 0, increases up to a certain limit Q, which is greater than P, and if the elastic limit be not exceeded the elongation increases uniformly with the stress, so that the internal work is equal to the mean stress $\frac{1}{2} Q$ multiplied by the total elongation y, or

$$k = \tfrac{1}{2} Q y.$$

Placing equal these two expressions for the work, thus neglecting the work that may be dissipated in heat, there results the equation

$$\tfrac{1}{2} Q y = P h + P y,$$

from which Q can be found when y is known. But, if e be the elongation due to the static load P, the law of proportionality within the elastic limit gives

$$y = \frac{Q}{P} e,$$

and inserting this, and solving for Q, there is found

$$Q = P\left(1 + \sqrt{1 + 2\frac{h}{e}}\right), \qquad (1)$$

which gives the momentary maximum stress. Substituting this value of Q there results

$$y = e\left(1 + \sqrt{1 + 2\frac{h}{e}}\right), \qquad (2)$$

which is the value of the momentary maximum elongation.

After this discussion we are now ready to give satisfactory definitions to the words "shock" and "suddenly applied force."

A shock results when the force P, before its action on the bar, is moving with velocity, as is the case when a weight P falls from a height h. The above formulas show that this height h may be small, if e is a small quantity, and yet very great stresses and deformations be produced. For instance, let $h = 4e$, then $Q = 4P$ and $y = 4e$; also let $h = 12e$, then $Q = 6P$ and $y = 6e$. Or take a wrought-iron bar 1 in. square and 5 ft. long; under a steady load of 5,000 lbs. this will be compressed about 0.0012 in., supposing that no lateral flexure occurs, but if a weight of 5,000 lbs. drops upon its end from the small height of 0.0048 in. there will be produced the stress of 20,000 lbs.

A suddenly applied force is one which acts with the uniform intensity P upon the end of the bar, but which has no velocity before acting upon it. This corresponds to the case of $h = 0$ in the above formulas, and gives $Q = 2P$ and $y = 2e$ for the maximum stress and maximum deformation. Probably the action of a rapidly-moving train upon a bridge produces stresses of this character.

I have been unable to find any experiments upon bars by which the above formulas can be tested. But in *Van Nostrand's Magazine* for October, 1877, there is an article on Momentum and Vis-viva by J. J. Skinner, in which are presented a number of experiments made upon spiral springs. These springs were suspended vertically and so arranged that falling weights caused them to elongate, and the amount of elongation was measured, as also the force required to cause the elongation. The elongations of the springs under static loads equal to the falling weights are not given, but these are easily determined from the other data and the statement that the stretch was always proportional to the weight, or, in other words, the elastic limit was not exceeded by the extreme stresses. The following are, then, the experimental data, the first column giving the number of the spring, the second that of the experiment, the third the weight in ounces of the falling objects, the fourth the heights in inches through which they fell before striking the spring, and the last the elongations in inches due to the same static weights.

Spring.	Exp.	P.	h.	e.
I	1	14.79	10.44	2.88
II	2	14.79	4.56	1.17
III	3	49.41	9.90	2.59
III	4	49.41	5.80	2.59
IV	5	49.41	10.26	2.59
IV	6	14.79	2.62	0.42
IV	7	14.79	7.72	0.42
IV	8	49.41	3.66	1.40
IV	9	49.41	7.79	1.40

Inserting the values of P, h, and e in formulas (1) and (2), the maximum stress Q and maximum elongation y are computed, and in the following table these are compared with the observed values of Q and y, the last column giving the mean per cent., in which the computed exceeds the observed value and which is very nearly the same for the stresses as for the elongations. Thus for the first experi-

ment the computed stress is 3.1 per cent. greater than that observed, and the computed elongation is 2.9 per cent. greater than that observed, the mean of these being 3.0 per cent. In no case do the two per cents. differ more than 0.2.

Exp.	Observed Q.	Computed Q.	Observed y.	Computed y.	Diff. per cent.
1	55.67	57.37	10.84	11.15	3.0
2	57.88	58.74	4.57	4.64	1.5
3	136.03	138.35	7.12	7.25	1.8
4	162.96	165.08	8.55	8.65	1.2
5	193.91	197.00	10.17	10.33	1.6
6	66.66	69.28	1.89	1.96	3.8
7	102.28	105.67	2.90	3.00	3.4
8	170.91	172.74	4.85	4.89	1.0
9	217.43	221.50	6.17	6.28	1.9

It is seen that for all the experiments the computed stresses and elongations are greater than those observed by from 1.0 to 3.8 per cent. That is to say, all the work of the falling weights was not immediately expended in producing elongation, but a small part was dissipated in heat either by the primitive impact or in other ways. When the falling weight P struck the spring it possessed the energy $P\,h$; when its lowest point of descent was reached the energy $P\,(h+y)$ was stored up in the spring, excepting the small amount lost in heat; after the completion of the oscillations the spring came to rest with the elongation e possessing the potential energy $\frac{1}{2}\,P\,e$, and then the total work $P\,(h+\frac{1}{2}\,e)$ had passed into heat.

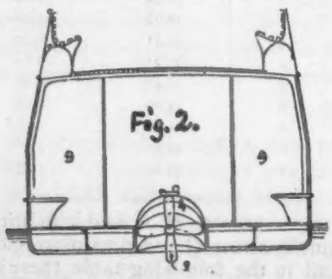
The discussion of the above experiments indicates that the theoretical formulas (1) and (2) closely represent the extreme stresses and deformations caused by shocks due to weights falling upon the end of a spiral spring, provided that the elastic limit of the material is not exceeded. Will a similar agreement exist in the case of stresses in bars caused by shocks? If so, it is clear that the factors of safety used in the past and at present in these cases are too low.

A PROPELLER FOR LIGHT-DRAFT BOATS.

(From *Le Yacht.*)

M. ORIOLLE, of Nantes, France, has devised a new method of propelling vessels of light draft with considerable speed by means of the ordinary screw-propeller.

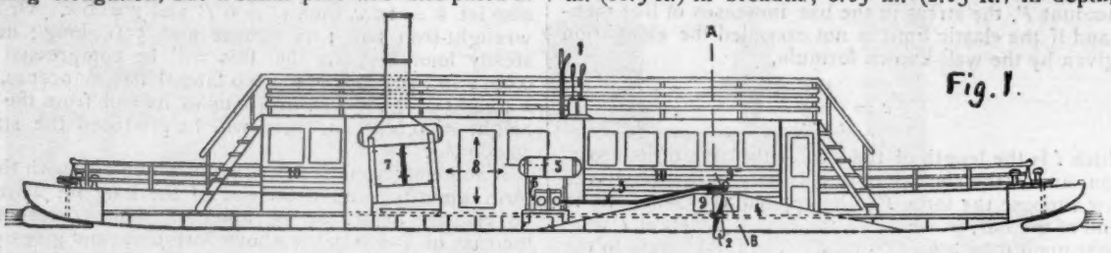
The screw, of suitable diameter for the engine power, is placed underneath the boat in a recess formed in the flat bottom. In cross-section this recess is semi-circular in form, as shown in fig. 2; in longitudinal section it slopes gradually both ways, fore and aft, from the screw, as shown in fig. 1.



The water is drawn in through an opening in the bottom of the boat forward of the screw and passes out through another opening behind it. The screw works in this way in a kind of siphon, in which a circulation is kept up by means of a pump, so that the whole effect of the screw is developed. The form of the siphon or passage is such that the circulation of the water through it will encounter the least possible resistance. In consequence of this arrangement, nearly all loss of power of the screw from centrifugal force is avoided, and the only diminution in the performance is that resulting from the diversion of the stream of water passing through the recess made for the screw.

In the accompanying cuts fig. 1 is a longitudinal section and fig. 2 a cross-section of the experimental boat, which is a double-ender, provided with a rudder at each end. Fig. 2 is on a somewhat larger scale than fig. 1. In these figures 1 is the steering apparatus; 2 the screw; 3 the suction-pipe of the pump; 4 the recess for the screw; 5 the engine; 6 the pump; 7 the boiler; 8 the fire-room; 9 a water-tight door through which access may be had to the screw for repairs, etc.; 10 is the passenger-room.

A boat built on this plan has given very good results so far as tried. This boat is 20 meters (65.6 ft.) long; 3.50 m. (11.5 ft.) in breadth; 0.65 m. (2.13 ft.) in depth, and draws only 0.25 m. (9.8 in.) of water. The screw is 0.85 m. (2.79 ft.) diameter, and 1.20 m. (3.94 ft.) pitch; the recess made for the screw in the flat bottom extends 3 m. (9 84 ft.) fore and aft of the screw itself.



On the trial trip, on a measured course of 1,850 meters (6,068 ft., or a nautical mile), the boat made a speed equivalent to 8.15 knots an hour, with a light pressure of steam (about 70 lbs.), 300 revolutions of the screw, and the engine developing 40 indicated H. P.

With a full pressure of steam, about 140 lbs., with which the screw can be run up to 450 revolutions, it is believed that there will be no difficulty in reaching a speed of at least 10 knots an hour.

A FRENCH EXPRESS PASSENGER LOCOMOTIVE.

THE accompanying illustrations show a heavy passenger engine exhibited at Paris by the Western Railroad Company of France, and built at the shops of that Company near Rouen. Formerly the type of passenger engine used on the road was one very common in France and on the Continent, with four coupled drivers and a single pair of leading wheels; but when it became necessary to build a heavier engine to meet the requirements of the increasing traffic, it was decided to substitute a truck for the leading wheels, and the present engine is the result. It was built from the designs of M. Clerault, Chief Engineer of Motive Power of the Company.

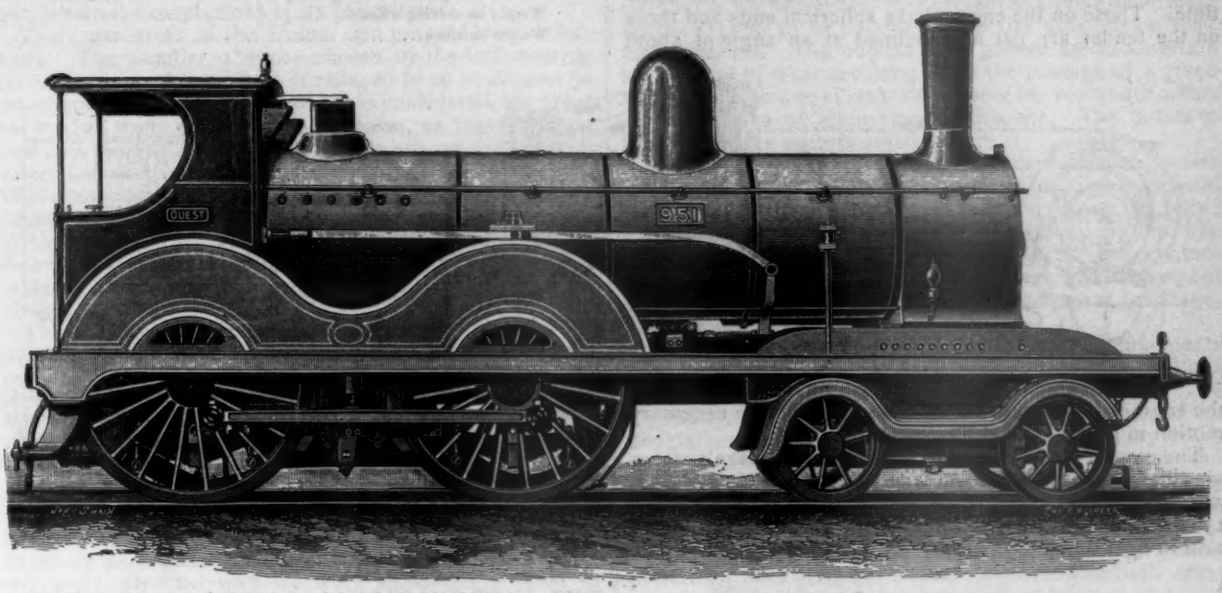
The boiler is of iron, in three rings joined by double butt joints; the fire-box of copper. The crown-bars are of steel made in a single plate, with ends extending beyond the box at each side, and carried on angle-brackets riveted to the sides of the outside fire-box. The smoke-box is of steel plate, but the smoke-box tube-plate is of copper, and the tubes are of brass. The grate is slightly inclined, and is fitted at the front end with a drop-plate worked by a screw.

The cylinders are inside, and the slide-valves are vertical and placed between the cylinders. Steam is taken into the single valve-chest, common to both cylinders, by two steam-pipes, one in front, the other behind. As there is little available space between the box and the slide-valves,

the ports are divided into two lengths, as shown in the smaller illustration, which gives a view of the valve-gear. The exhaust is divided into two branches passing, one straight up, the other below and around the cylinder. The pistons are of the Swedish type, made of forged steel. There are four guide-bars which are arranged in a somewhat novel manner, which is also shown in the smaller engraving. The bars are supported at the center of their length, independently of the cylinder, by a steel casting bolted between the side frames. The valve-gear is a link motion with box-links. The reverse shaft is not fitted with any balancing weight or spring, reversing being effected by the steam apparatus, which is illustrated separately herewith.

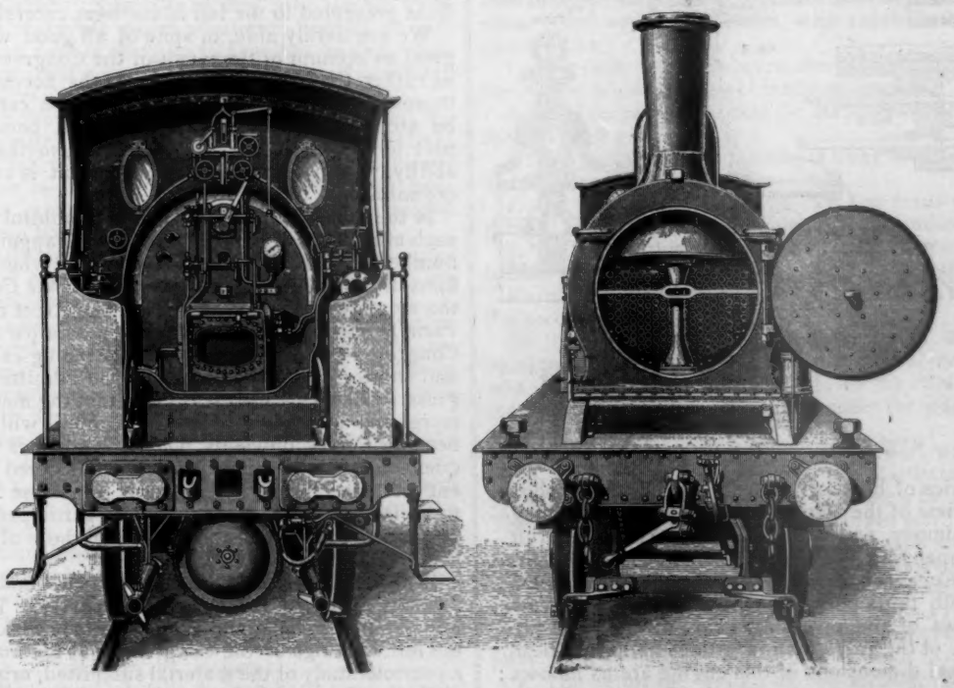
This reversing apparatus is shown in the small engraving, figs. 1–5. Fig. 1 shows the apparatus complete, *E* being the reverse lever and *C* a multiple passage cock on the cylinder; this cock is shown in detail in fig. 4. Fig. 5 is a diagram of the whole arrangement. The reversing shaft is moved by a steam cylinder and piston, controlled by a cataract or water cylinder, which serves to lock the gear in any position.

The connecting-rods are of channeled section. The coupling rods are of mild steel, also of channeled section, made with both ends solid. The coupling pins are placed at the same side of the centers as the main cranks on the axles. The whole of the revolving weight and about one-third of the reciprocating weight is balanced, one-sixth of the latter in each pair of coupled wheels.



EXPRESS LOCOMOTIVE, WESTERN RAILROAD OF FRANCE.

The frames are of the plate type, and are of steel 1 in. thick. Beneath the cylinders is a flat casting which carries the center-pin of the truck. The center-plate on the truck is circular and 2 ft. in diameter, with a projection 9½ in. diameter and 7½ in. long, and through this projection the center-pin, which is 3 in. in diameter, passes. This center-pin is slightly in the rear of the actual center of the truck, an arrangement which is said to give greater ease in going around curves. The truck frames are also of steel plate 1 in. thick. The truck has a slight transverse motion controlled by two plate springs, with an initial ten-



sion of about 1½ tons and a deflection of about 1 in. per ton.

The driving-springs are beneath the axle-boxes, as will be seen, and are connected by an equalizing lever. The axle-boxes are of cast steel. The engine and tender are coupled without the usual spring buffers by oblique buffers, a system which has been in use on this road for some time. Those on the engine have spherical ends and those on the tender are flat and inclined at an angle of about

Total wheel-base	22 ft.	4 in.
Distance between centers of driving-wheels	8 "	11 "
Diameter of driving-wheels	6 "	8½ "
Diameter of truck-wheels	3 "	1 "
Diameter of cylinders		18 "
Stroke of cylinders		26 "
Weight of engine in working order		47½ tons
Weight on driving-wheels		29 "
Weight on truck		18½ "

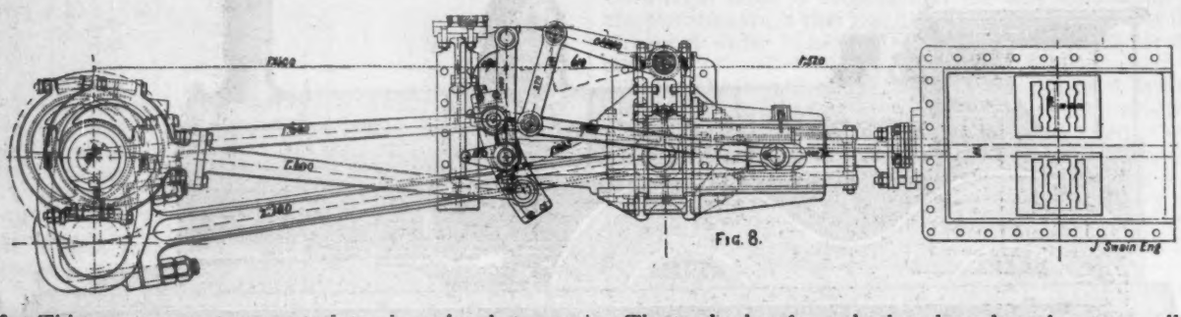
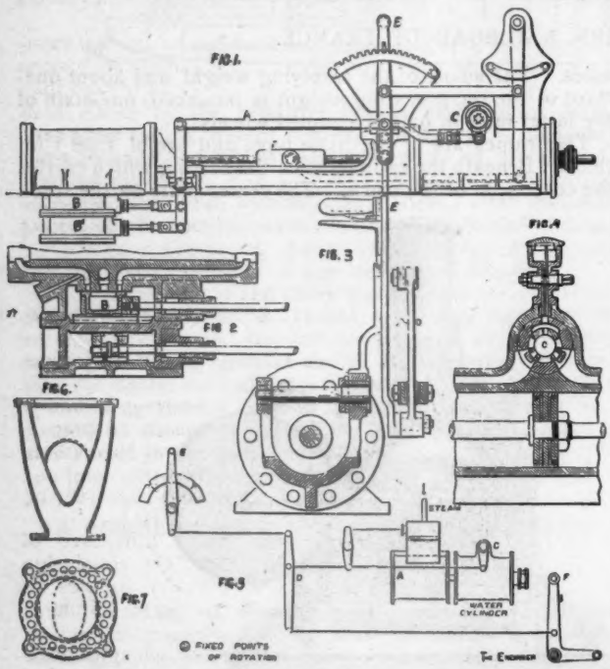


FIG. 8.

50°. This arrangement prevents lateral motion between the engine and tender, but does not prevent the necessary motion in going around a curve.

The engine is provided with Gresham & Craven's steam sanding apparatus. The boiler is fed by two No. 9 Friedman injectors, and the usual working pressure carried is 156 lbs. The blast-pipe, which is shown in section and in plan in figs. 6 and 7, is of the "Vortex" type; above it is



placed a species of hood or petticoat pipe, which is shown in the front view of the engine. This is really a prolongation of the chimney, and is intended to equalize the draft.

The accompanying illustrations, which are taken from the London *Engineer*, show a side view of the engine; a front view with the smoke-box door open; a rear view; enlarged views of the reversing gear, of the blast-pipe, and, in fig. 8, of the valve motion, guides and cross-head.

The principal dimensions of this engine are as follows:

Length of grate	5 ft.	7 in.
Width of grate	3 "	5 "
Depth of fire-box	5 "	6 "
Number of tubes		195
Diameter of tubes outside		2 in.
Length of tubes	13 ft.	8½ "
Diameter of boiler	4 "	1 "
Height of center of boiler above rail	7 "	3 "
Length of engine over all	33 "	5 "

The tender has four wheels only and carries 2,300 galls. of water, which is a sufficient supply for the run from Paris to Rouen, 86 miles. The wheel-base of the tender is 9 ft. 8 in.; great care has been taken to keep down its weight as much as possible. Its total weight ready for work is only 25 tons, and of this the water weighs nearly 10 tons and the coal 3¼ tons.

THE INTERNATIONAL RAILROAD CONGRESS.

[Dr. Victor Roll, in *Zeitschrift für Eisenbahnen und Dampfschiffahrt*, Vienna.]

A PROMINENT French journal characterizes the proceedings of the Congress in these words: "The discussions on most of the points were long and careful, and the resolutions presented to the full house were carefully prepared."

We are hardly able, in spite of all good will, to hold so good an opinion of the result of the Congress; it seems to us rather that in the proceedings the necessary care and thoroughness were wanting. The fault certainly cannot be attributed to the many prominent persons who took part in the Congress, and who tried, to the best of their ability, to forward its objects; the fault is rather with the organization.

In the first place, it seems to be of doubtful propriety that each management should be allowed to appoint an optional number of representatives, each one of whom appears for himself as an independent member of the Congress; that the most insignificant local roads and street railroads—the Paris Exposition Railroad appeared as a participant in the Congress—car-trust companies, sleeping-car companies, and similar organizations should be admitted to the Congress. On such a plan it is clear that the membership will increase to many hundred persons, and it will consequently become a very unwieldy body. Now it is true that the questions to be discussed will be considered in the different sections; but how do we find it in these? These sections include each more than 100 participants, and their sessions begin at the same time with those of the full Congress.

With this arrangement it is not to be wondered at if the discussions in the sections also miscarry. The too great number of members, and the necessity of making ready for the full meetings of the Congress, and the impossibility of a previous study of the material submitted, cripple the work of the sections, with the result that the conclusions of the reports will not always be the full solution of the problem in hand.

It will appear that from these causes the debates in Paris were still more unfavorably influenced than in the earlier meetings. Men like M. de Bruyn—now the Belgian Minister of Public Works—who led the discussion in the Fifth Section at the Milan and Brussels meetings; Leon Say, who took an active part in the Fourth Section, and others

of weight, were this time unheard, and but seldom gave a word to stir up the discussion.

It would be well to call to mind the example of the German Railroad Union. That body, which numbers in all fewer members than one section of the Railroad Congress, is a representative assembly, which usually accepts without debate the conclusions of its committees.

The committees of the Union also proceed very differently. The number of those chosen by the full meeting for the strongest committee is reduced to 20 or at most 30 members. And even this number is considered too great for the full study of important questions, so that the usual course is to appoint sub-committees to sift out the material submitted and to prepare a summary for their consideration. These summaries and the reports must be sent at least 14 days before the beginning of the meeting to all members of the committee. The committees are assigned a time for meeting before the general meeting, and their reports must be sent before the meeting to all members of the Union.

These arrangements necessarily result in reducing the number of the members of the full meeting and of the sections by regular rules, in completing the work of the sections before the general meeting, and in placing before the members full information on the subject in hand. Thus there is no possibility of the members acting upon insufficient information, or taking part in the debates without understanding fully the question in hand.

On the other hand, it would be very strange if the members of the International Congress could master in a few days—or perhaps hours—the thick volumes, which those who were intrusted with the work submitted to them, in order to take part properly in the discussion.

It must also be said that the work of these gentlemen leaves much to be desired. Truth requires us to say that, while in the majority of the special papers no pains were spared to present a general view of the condition of the question in hand in different countries, their labor alone was too often in vain ; the view was too limited, because the questions addressed to the railroad managements remained unanswered. Now it is of very little use for us to learn from an elaborate paper what one French, or Belgian, or Russian road is doing in this or that matter, when we do not know what a hundred other important roads are doing in the same direction.

This result is the more to be regretted, because, had the railroads, generally, taken such interest and given such data as were asked for, a body of information of almost inestimable value as to current railroad practice might have been collected, upon which most valuable conclusions might have been based for future use.

But these criticisms must be sufficient, and must give place to a brief account of what was done, following the programme laid down in advance.

Beginning with Section I, we find that in that division there were seven questions : The first—Question A—related to the Best Material for Rails. Under this head were reported the results obtained by the use of different kinds of steel for rails and rail-joints.

Upon this point M. Von Bricka, Chief Engineer of the French State Railroads, presented results obtained on several French, Austro-Hungarian, Belgian, Swiss, and English lines, on the Spanish State Railroad, and the Swedish Northern. On this question also there were presented notes from Councillor Werchowsky on the researches on steel rails made by the Russian Technical Society, and from M. Hallopeau on the behavior of steel on the Paris, Lyons & Mediterranean lines.

The Congress agreed with the report, and adopted the following vote prepared in the Section :

For the manufacture of rails a very hard steel is to be preferred, provided it be of good quality and nearly free from phosphorus. The greatest possible degree of hardness that can be obtained without injuring the quality of the steel depends upon the methods used in its manufacture and upon the raw material used. The use of steel for rail fastenings is continually increasing ; for the joint-plates steel of medium hardness is preferred ; for the bolts and spikes soft steel (flusseisen).

Question B related to the rules governing the wear of rails. On this point an elaborate paper was read by M. Louis de Busschere,* Chief Engineer of the Belgian State Railroads. His opinion was that the experiences reported under this head were not sufficiently extended to establish any general rules, and he recommended a careful series of observations, on which a report could be based for the next meeting of the Congress. He presented a table or formula for the reports to be obtained from the different railroad managements. The objects to be gained are to ascertain the amount of wear resulting from the passage of a given number of trains or of tons weight over the rail under differing conditions of alignment, grades, etc. The points to be noted in the reports asked for are :

Method of laying the rails ; characteristics of section chosen for observation ; maximum grade and minimum radius of curvature ; method of manufacture of the rails ; endurance per square millimeter of wear ; length of the rails ; section of the rails ; weight per meter ; average moment of inertia ; greatest weight on an axle ; average age of the rails ; number of rails removed on account of breakage, longitudinal cracks, or any other cause.

The report was approved and the different managements were requested to make the trials, on one or more sections of road.

Question II, A, related to the comparative merits of the double-headed and Vignoles rails for lines of very heavy traffic. The report made by MM. de Bemelmans and Brunerel, of the Belgian State Railroads, gave a summary of the history of this question. The report, with which the Section agreed, recommended the double-head rail for lines with heavy traffic and fast trains, and the Vignoles pattern for lines of lighter traffic. Nevertheless both forms of rail are considered safe when well made.

It is to be noted, however, that, owing to the few managements which answered the questions, these conclusions were rather based on the experience of a single road than on any comparison of general practice.

Division B treated of the best method of fastening rails (Vignoles type) to wooden ties, by screw-spikes or ordinary spikes. The report on this subject was made by Herr Hohenegger, Engineer of Maintenance of Way of the Austrian Northwestern Railroad, who reached the following conclusions :

1. The ratio 90:100 between the breadth of the base and the height of the rail is generally preferable.
2. Steel tie-plates increase the stability of the superstructure on high grades.
3. The perforation of the ties is done best by the wedge-shaped spike.
4. On the inner side of the rail the screw-spike shows greater endurance, on the outer side the ordinary spike.
5. Spikes offer more resistance than screw-spikes both to lateral movement and to creeping of the rails.

Further investigations were held desirable, especially on the second point.

On this point also there was much difference of opinion in the Section. As to the others, the conclusion was that the spike is to be preferred for cold climates, or for ties of soft wood ; the screw-spike for warm climates, or for hard-wood ties.

In Division C, on Rail-joints, the report was presented by M. Pieron, Chief Engineer of the Northern Railroad of France, and related chiefly to experience in that country. The conclusions reached by the Section were as follows :

1. In relation to the rail-joint, the suspended joint (between ties) seems to be generally preferred to the supported joint (resting on tie). The distance between the joint ties varies from 60 to 70 cm. (23.6 to 27.6 in.).
2. The angle-plate offers no advantages over the straight joint-plate or fish-plate.
3. The better the design of rail-section, the lighter can the joint be made.
4. The number of bolts to a joint is usually four.
5. To prevent bolts becoming loose, the only remedy is to screw the nuts up as tight as possible.

Division D was the question of the best permanent way for lines where trains are run at high speed. The report was made by M. Michel, Chief Engineer of the Paris,

* A summary of M. Busschere's paper was published in the RAILROAD AND ENGINEERING JOURNAL for November.

Lyons & Mediterranean Railroad, and the decisions of the Section are given below :

Rails : The weight of the rails can, for the double-headed type, vary from 40 to 45 kg. per meter (80 to 90 lbs. per yard) ; for the Vignoles type, from 42 to 52 kg. per meter (85 to 105 lbs. per yard). The length of the rail should be from 9 to 12 meters (29.5 to 39.4 ft.) and the width of the rail-head from 60 to 72 mm. (2.36 to 2.83 in.).

Fastenings : The rail should have three or four fastenings to each tie. For the Vignoles type the screw-spike is preferred.

Joints : The splice-bars should be as long and heavy as possible. The general practice is to use the angle-joint.

Ties : The distance between joint-ties should be from 48 to 66 cm. (19 to 26 in.) ; between the other ties, from 75 to 91 cm. (29.5 to 35.8 in.).

Ballast : The main point is that care should be taken in the choice of materials.

Road-bed : The main points are that the road-bed should be thoroughly drained and ample support provided for the ties.

Locomotives : The type of engine most used for high speed is now that having a truck forward.

In the discussion on this question many interesting facts were brought out as to the effect of fast trains on the track, and on other points.

Question III brought up the point whether in laying track on iron bridges it is best to interpose wood between the rails and the bridge girders ; and whether it is best to lay the track on longitudinal sleepers or cross-ties. The report was presented by Sr. Randich, of Italy, and the conclusions reached were somewhat indefinite. It was considered that neither system presented such advantages as would warrant a general expression of preference. The use of iron cross-ties was thought to present some advantages.

Under Question IV, the operation of signals and switches from a distance, or from a central station, M. Sabouret, of the Orleans Railroad (France) presented a careful report on the practice on different lines.

The conclusions of the Congress were that, while the system to be adopted must depend largely upon local conditions, in general terms it might be said that for distances up to 50 meters the transmission of the required power to operate the signals or switches by rigid rods or bars was to be preferred ; from 50 to 200 meters the choice must depend upon the circumstances in each case ; over 200 meters the transmission by wire ropes must be considered preferable. As to hydraulic, pneumatic, and electric transmission, their use is still too limited to permit any general rules.

Question V related to the best means of transferring cars from one track to another parallel one—switching, turn-tables, or transfer-tables. The report was presented by M. Briere, of the Orleans Railroad, and the Section recommended in general terms the use of transfer-tables, while admitting that local conditions must largely govern the means adopted.

Question VI—the Ventilation of Tunnels—was presented in a report by Sr. Candellero, of Italy. This was considered by the Second and Third Sections together, and the conclusion was that further trials with natural and artificial ventilation were very desirable ; also trials of apparatus for ventilating properly and removing from the tunnel smoke, gas, etc.

Question VII was divided into three parts. Under Division A, Herr von Leber, of the Austrian General Inspection, presented a long report in two parts, the first suggesting a fixed nomenclature for bridge construction and parts of bridges ; the second giving rules and formulas for bridges of different material (steel, mild steel, and iron), for limits of safety, strains, etc. His suggestions were approved by the Congress.

Under Division B, M. Von Bricka, of the French State Railroads, presented a long report on the breakage of rails, treating of the causes of breakage, material of rails, manner of breakage, effects of temperature on breakage, and many other points.

Under Division C, M. Kowalski, of the Bona-Guelma Railroad (Algiers), presented a report on the use of metallic ties, which was supplemented by notes from the Netherlands State Railroad and from several Swiss lines.* The conclusion reached was that, while metallic ties present many favorable points, the experience with them was not yet extended enough to warrant any final decision in their favor as against wooden ties.

The Section and the Congress adopted the suggestion made in the report for further trials. This was that each management should select two trial sections of 500 to 1,000 meters each, one to be laid with metal ties, the other with new wooden ties ; both to be as nearly as possible under the same conditions of grade, curvature, drainage, condition of road-bed, ballast, etc. The points to be observed and reported are first cost ; cost of maintenance ; cost of renewals ; durability or life of ties ; effect on rails ; best types or forms of tie, and general cost, taking into consideration all renewals. These trials should last some time in order to arrive at a just conclusion.

(TO BE CONTINUED.)

EXPERIMENTAL AID IN DESIGNING STEAMSHIPS.

(From the *Steamship.*)

THE achievement of one triumph after another in the matter of high-speed steamships, and especially the confidence with which pledges of certain results are given and accepted long before actual trials are made, form one of the most convincing proofs of the important part which scientific methods play in modern shipbuilding. This is evident in the case of ships embodying novel or hitherto untried features, and more especially so in cases where shipbuilders, having no previous personal practical experience or data, achieve such results. This was notably illustrated in the case of the Fairfield Company undertaking some five years ago to build and engine a huge craft of most phenomenal form and proportions, and to propel the vessel at a given speed under conditions which appeared highly impracticable to many engaged in the same profession. The contract was proceeded with, however, and the Czar of Russia's wonderful yacht *Livadia* was the result, which (however much she may have justified the professional strictures as to form and proportions) entirely answered the designer's anticipations as to speed. Equally remarkable and far more interesting instances are the Inman liners *City of Paris* and *City of New York*, in whose design there was sufficient novelty to warrant the degree of misgiving which undoubtedly existed regarding the Messrs. Thomson's ability to attain the speed required. In the case at least of the *City of Paris*, Messrs. Thomson's intrepidity has been triumphantly justified. An instance still more apposite to our present subject is found in the now renowned Channel steamers *Princess Henrietta* and *Princess Josephine*, built by Messrs. Denny, of Dumbarton, for the Belgian Government. The speed stipulated for in this case was 20½ knots, and although in one or two previous Channel steamers, built by the Fairfield Company, a like speed had been achieved, still the guaranteeing of this speed by Messrs. Denny was remarkable, in so far as the firm had never produced or had to do with any craft faster than 15 or 16 knots. The attainment not only of the speed guaranteed, but of the better part of a knot in excess of that speed, was triumphant testimony to the skill and care brought to bear upon the undertaking. In this case, at least, the result was not one due to a previous course of "trial-and-error" with actual ships, but was distinctly due to superior practical skill, backed and enhanced by knowledge and use of specialized branches in the science of Marine Architecture. Messrs. Denny are the only firm of private shipbuilders possessing an Experimental Tank for recording the speed and resistance of ships by means of miniature reproductions of the actual vessels, and to this fact may safely be ascribed their confidence in guaranteeing, and their success in obtaining, a speed so remarkable in itself and so much in excess of

* The note on the experience of the Swiss lines with iron ties was translated and published in the RAILROAD AND ENGINEERING JOURNAL for October.

anything they had previously had to do with. Confirmatory evidence of their success with the Belgian steamers is afforded by the fact that they have recently been instructed to build for service between Stranraer and Larne a paddle-steamer guaranteed to steam 19 knots, and have had inquiries as to other high-speed vessels.

In estimating the power required for vessels of unusual types or of abnormal speed, where empirical formulæ do not apply, and where data for previous ships are not available, the system of experimenting with models is the only trustworthy expedient. In the case of the Czar's extraordinary yacht, the *Livadia*, already referred to, it may be remembered that, previous to the work of construction being proceeded with, experiments were made with a small model of the vessel by the late Dr. Tideman, at the Government Tank at Amsterdam. On the strength of the data so obtained, coupled with the results of trials made with a miniature of the actual vessel on Loch Lomond, those responsible for her stipulated speed were satisfied that it could be attained. The actual results amply justified the reliance placed upon such experiments. The design of many of Her Majesty's ships have been altered after trials with their models. This was notably the case in connection with the design of the *Medway* class of river gunboats. The Admiralty constructors at first determined to make them 110 ft. long, by only 26 ft. in breadth. A doubt arising in their minds, the matter was referred to the late Mr. Froude, who had models made of various breadths, with which he experimented. The results satisfied the Admiralty officers that a substantial gain, rather than a loss, would follow from giving them much greater beam than had been proposed, and this was amply verified in the actual ships.

So long ago as the last decade of last century, an extended series of experiments with variously-shaped bodies, ship as well as other shapes, were conducted by Colonel Beaufoy, in Greenland Dock, London, under the auspices of a Society instituted to improve Naval Architecture at that time. Robert Fulton, of America, David Napier, of Glasgow, and other pioneers of the steamship, are related to have carried out systematic model experiments, although of a rude kind in modern eyes, before entering on some of their ventures. About 1840 Mr. John Scott Russell carried on, on behalf of the British Association, of which he was at that time one of its most distinguished members, an elaborate series of investigations into the form of least resistance in vessels. For this purpose he leased Virginia House and grounds, a former residence of Roger Stewart, a famous Greenock shipowner of the early part of the century, the house being used as offices, while in the grounds an experimental tank was erected. In it tests were made of the speed and resistance of the various forms which Mr. Russell's ingenuity evolved—notably those based on the well-known steam line theory—as possible types of the steam fleets of the future. All the data derived from experiment was tabulated, or shown graphically in the form of diagrams, which, doubtless, proved of great interest to the *savants* of the British Association of that day. Mr. Russell returned to London in 1844, and the investigations were discontinued.

It will thus be seen that model experiments had been made by investigators long before the time of the late Dr. William Froude, of Torquay. It was not, however, until this gentleman took the subject of resistance of vessels in hand that designers were enabled to render the results from model trials accurately applicable to vessels of full size. This was principally due to his enunciation and verification by experiment of what is now known as the "law of comparison," or the law by which one is enabled to refer accurately the resistance of a model to one of a larger size, or to that of a full-sized vessel. In effect, the law is this—for vessels of the same proportional dimensions, or, as designers say, of the same lines, there are speeds appropriate to these vessels, which vary as the square roots of the ratio of their dimensions, and at these appropriate speeds the resistances will vary as the cubes of these dimensions. The fundament upon which the law is based has recently been shown to have found expression in the works of F. Reech, a distinguished French scientist, who wrote early in the century. There are no valid grounds for supposing that the discovery of Reech was familiar to Froude; but even were this so, it is abundantly evident that, although never claimed by himself, there are the best of grounds for claiming the law of comparison, as now established, to be an independent discovery of Froude's.

Dr. Froude began his investigations with ships' models at the experimental tank at Torquay about 1872, carrying it on uninterruptedly until his death in 1879. Since his decease, the work of investigation has been carried on by his son, Mr. R. E. Froude, who ably assisted his father, and originated much of the existing apparatus. At the beginning of 1886 the whole experimental appliances and effects were removed from Torquay to Haslar, near Portsmouth, where a larger tank and more commodious offices have been constructed, with a view to entering even more extensively upon the work of experimental investigation. The dimensions of the old tank were 280 ft. in length, 36 ft. in width, and 10 ft. in depth. The new one is about 400 ft. long, 20 ft. wide, and 9 ft. deep. The new establishment is more commodious and better equipped than the old, and although the experiments are taken over a greater length, the operators are enabled to turn out results with as great dispatch as in the Torquay tank. The adjacency of the new tank to the dockyard at Portsmouth enables the Admiralty authorities to make fuller and more frequent use of it than formerly. Since the value of the work carried on for the British Government has become appreciated, several experimental establishments of a similar character have been instituted in other countries. The Dutch Government in 1874 formed one at Amsterdam which, up till his death in 1883, was under the superintendence of Dr. Tideman, whose labors in this direction were second only to those of the late Dr. Froude. In 1877 the French naval authorities established an experimental tank in the dockyard at Brest, and the Italian Government have just completed one on an elaborate scale in the naval dockyard at Spezzia. The Spezzia tank, which is 500 ft. in length by about 22 ft. in breadth, is fully equipped with all the special and highly ingenious instruments and appliances which the scientific skill of the late Dr. Froude brought into existence, and have been since his day improved upon by his son, Mr. R. E. Froude, and other experts. Through the courtesy of our own Admiralty and of Messrs. Denny, of Dumbarton, the Italians have been permitted to avail themselves of the latest improvements which experience has suggested, and the construction of the special machinery and apparatus required has been executed by firms in this country having previous experience in this connection.

Having briefly traced the origin and development of the system of model experiment, it may now be of interest to describe the *modus operandi* of such experiments, and explain the way in which they are made applicable to actual ships. The models with which experiments are made in those establishments conducted on the lines instituted by Mr. Froude, are made of paraffin wax, a material well adapted for the purpose, being easily worked, impervious to water, and yielding a fine smooth surface. Moreover, when finished with, the models may be remelted for further use and all pairings utilized. They are produced in the following manner: A mold is formed in clay by means of cross-sections made somewhat larger than is actually required, this allowance being made to admit of the cutting and pairng afterward required to bring the model to the correct point. In this mold a core is placed, consisting of a light wooden framework covered with calico and coated with a thick solution of clay to make it impervious to the melted paraffin. This latter substance is run into the space between the core and the mold and allowed to cool. This space, forming the thickness of the model, is usually from ¾ in. for a model of 10 ft. long to 1¼ in. and 1½ in. for one of 16 and 18 ft. long. When cold, the model is floated out of the mold by water pressure and placed bottom upward on the bed of a shaping machine, an ingenious piece of mechanism devised by the late Dr. Froude, to aid in reducing the rough casting to the accurate form. The bed of this machine, which travels automatically while the machine is in operation, can be raised or lowered to any desired level by adjusting screws. A plan of waterlines of the vessel to be modeled is placed on a tablet

geared to the machine, the travel of which is a function of the travel of the bed containing the model. With a pointer, which is connected by a system of levers to the cutting tools, the operator traces out the water-lines upon the plan as the machine and its bed are in motion, with the result that corresponding lines are cut upon the model. The cutting tools are swiftly revolving knives which work on vertical spindles moved in a lateral direction (brought near or removed from each other), according to the varying breadth of the water-lines throughout the length of the model, as traced out by the operator's pointer. In this way a series of longitudinal incisions is made on the model at different levels corresponding to the water-lines of the vessel. The model is now taken from the bed of the machine and the superfluous material, or projection between the incisions, is removed by means of a spokeshave, or other sharp hand-tool, and the whole surface brought to the correct form and made fair and smooth.

To test accuracy of form, the weight of the model is carefully taken, and the displacement at the intended trial draft accurately determined from the plan of lines. The difference between the weight of the model and the displacement at the draft intended is then put into the bottom of the model in the form of small bags of shot, and by unique and very delicately constructed instruments for ascertaining the correct draft, the smallest error can at once be detected and allowed for. The models vary in size from about one-tenth to one-thirtieth of the size of the actual ship. A model of the largest size can be produced and its resistance determined at a number of speeds in about two days or so.

The mode of procedure in arranging the model for the resistance experiment, after it is afloat in the tank at the correct draft and trim, consists in attaching it to a skillfully devised dynamometric apparatus secured to a lightly constructed carriage. This carriage runs on a railroad which extends the whole length of the tank about 15 in. or 18 in. above the water. The floating model is carefully guided in its passage through the water by a delicate device, which keeps it deviating either to the right or the left, but at the same time allows a free vertical and horizontal motion. The carriage, with the model attached, is propelled by an endless steel wire rope, passing at each end of the tank around a drum driven by a small stationary engine, fitted with a very sensitive governor, capable of being so adjusted as to give any required speed to the carriage and model. The resistance which the model encounters in its passage through the water is communicated to a spiral spring, and the extension this spring undergoes is the measure of the model's resistance. The amount of the extension is recorded on a revolving cylinder to a much enlarged scale through the medium of levers or bell-cranks, supported by steel knife-edges resting on rocking-pieces. On the same cylinder are registered time and distance diagrams, by which a correct measure of the speed is obtained. The time diagram is recorded by means of a clock attached to an electric circuit, making contact every half-second, and actuating a pen which forms an indent on what would otherwise be a straight line on the paper. The distance-pen, by a similar arrangement, traces another line on the cylinder.

From these time and distance diagrams accurate account can be taken of the speed at which the model and its supporting carriage have been driven. Thus, on the same cylinder are recorded graphically the speed and resistance of the model. The carriage may be driven at any assigned speed by adjusting the governor of the driving engine.

When the resistances of the model have been obtained at several speeds, varying in some cases from 50 ft. to 1,000 ft. per minute, the speeds are set off in suitable units along a base-line, and for every speed at which resistance is measured, the resistance is set off to scale as an ordinate value at those speeds. A line passing through these points forms the curve of resistance, from which the resistance experienced by the model at the given trial speeds, or any intermediate speed, can be ascertained. The resistance being known, the power required to overcome it and drive the ship at any given speed is easily deduced by applying the rule before described as the law of comparison.

A COMPOUND STEAM FORGING PRESS.

(From *Industries*.)

THE accompanying illustrations, figs. 1 and 2, represent a general view and a front elevation of a compound steam forging press, now being introduced by Messrs. B. & S.

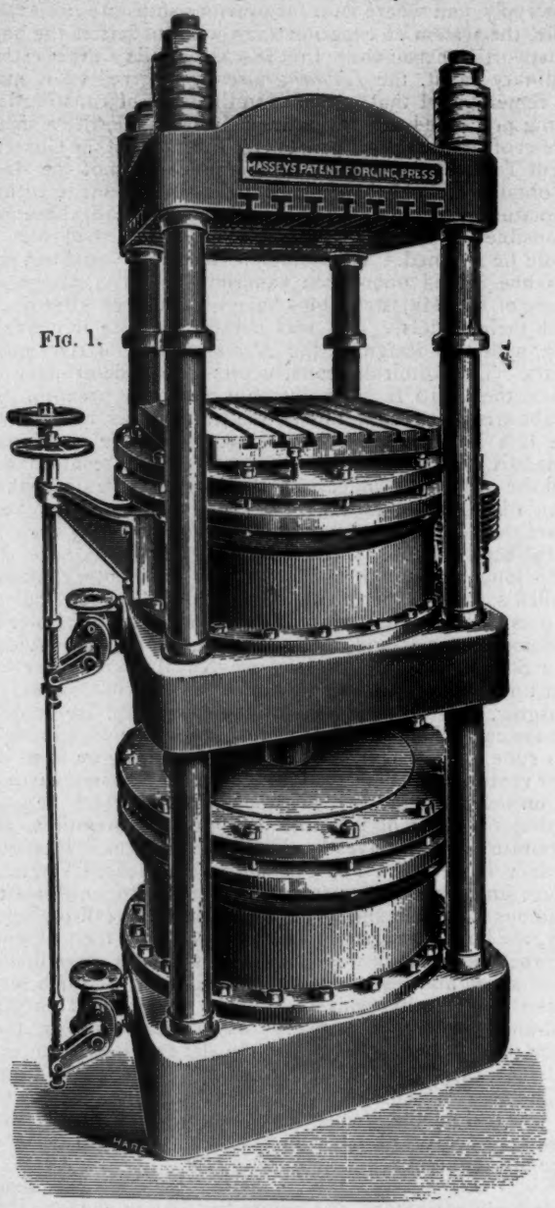
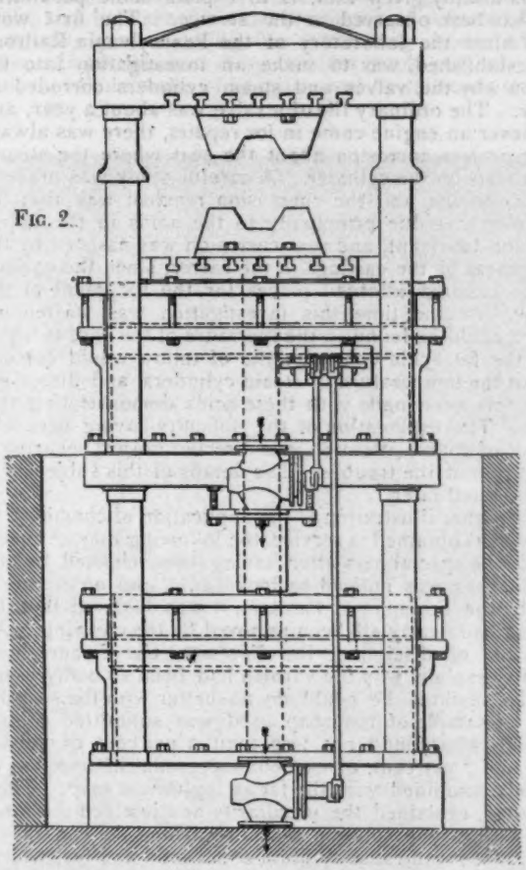


FIG. 1.

Massey, engineers, Openshaw, near Manchester, England. The makers, while recognizing the advantages of pressure forging, have also foreseen the necessity of plant less costly than that usually worked by hydraulic pressure. The press under notice is capable of exerting a maximum pressure of 100 tons with steam pressure at 60 lbs. per square inch, and it will be readily understood that this pressure can be augmented either by simply increasing the steam pressure or the number or diameter of the steam cylinders. In this case the two cylinders—each 49½ in. diameter—are placed one above the other, the piston-rod of the lower one being arranged to work through the upper cylinder, the stroke in both cases being 15 in. Steam is admitted direct from the boiler into the cylinders, the valves being so arranged that the pistons can be worked either conjointly or separately as required. Thus for light work one cylinder alone can be used, or, while one piston is made to act upon a pair of dies, the other piston can

drive a punch through the metal held in the dies. The height between the table and the top, when the former is in its lowest position, is 24 in. The table itself measures 4 ft. 2 in. square, is provided with T grooves on its upper surface for fixing the tools, and is guided between four massive pillars. We are informed that Messrs. Massey have one of these presses working at 60 lbs. pressure at their own works, and forging in it 2¾-in. square-headed bolts at one stroke, in common cast-iron dies. The makers claim for this press several advantages—viz., small first

FIG. 2.



cost; cheapness of erection, a steam pipe from the boiler being the only fixing required; cheapness of working; speed in action, in consequence of the elastic property of steam; and absence of vibration or noise during working.

AN ENGLISH VIEW OF OUR NAVY.

(From the *Army and Navy Gazette.*)

THE announcement made within the last day or so that a squadron of United States men-of-war of modern construction will shortly arrive in European waters serves to remind us of the notable results of the new departure in regard to naval matters taken during the administration of ex-President Cleveland. One of the most important arguments used by Lord George Hamilton when introducing his resolution on the Navy in March last, was based upon the unusual tendency which so many powers have recently shown to increase their naval strength. As the First Lord pointed out with much force 18 years ago, or even less, there was only one considerable naval power in Europe, while the feature of the present situation is that there are now not one or two, but four or five nations which are spending largely on their naval armament. Italy, Germany, and Austria, but especially the first-named power, have practically created navies since the time when Mr. Childers was at the Admiralty. Russia, too, whose navy then was almost entirely built for defense, is now strong on the seas for offense as well; while we cannot forget that Turkey, which had a fairly good fleet, no longer possesses one. Other powers, like Brazil, Chili, Japan and China, have acquired some remarkably fine and powerful ships; and, more recently, Spain has evinced a determination to re-enter the arena on which so many of her former successes were gained and her former prowess was so frequently exhibited. But though it may be that it is with the increase of European navies we are principally concerned, Englishmen cannot help being interested also in the remarkable strides which have been taken in this direction on the other side of the Atlantic, where the rehabilitation of the Navy of the United States is being pushed ahead with the characteristic energy of our American cousins. If, perchance, there are any who have not taken note of what there is going on, the imminent advent of four new and important cruisers in our waters should direct their attention that way. It is not so much, however, that the United States have made a very good beginning toward building up a modern Navy—this is but a trifle where "money is no object"—but there have also been developed in the country facilities of every kind for the creation of that Navy without outside assistance. This can hardly yet be said of any other power except France and Great Britain. In 1885, it was not only the case that the United States had no vessel-of-war which could have kept the seas for one week as against any first-rate naval power, but they were absolutely dependent upon our manufactories for forging of guns, for armor, for machine and rapid-fire guns, and the like. Now, four years later, not only has much been done in the way of constructing vessels which are as good as anything of similar type afloat, but arrangements have been made by which they will be able shortly to create entirely from their own resources every modern implement of war, including steel-clad battleships of the heaviest tonnage, with their guns and armor. By the end of this year the Bethlehem Iron Company, of Bethlehem, Pa., one of the largest steel manufactories in the States, has guaranteed to have erected the plant for the production of armor and gun forgings of the largest kind. Other companies have taken in hand the supply of war material, and within the last month three or four firms have tendered for the construction of cruisers and a similar number for the provision of steel projectiles. Moreover, there is now nearly completed at Washington an ordnance factory for finishing heavy naval ordnance, and all the necessary plant for handling gun-forgings up to the quantity required to make the very largest gun afloat. Nearly half a million sterling has been expended, or is in course of expenditure, on this factory alone. Of developments which we may call by comparison minor, there is the opening of a new dock, 460 ft. by 79 ft. by 27½ ft., at Mare Island, San Francisco, and another at Norfolk, Va., within the last fortnight, which is 600 ft. by 93 ft. by 25 ft. The Americans have quite evidently realized that as they are obliged to spend money on a Navy, the disbursements may as well be for their own benefit as not. In fact, ex-Secretary of the Navy Whitney, to whose exceptional executive talents and business ability these results are mainly due, might well have used in his valedictory address the words used by Lord George Hamilton not long ago:

"The great bulk of expenditure in the Navy goes in the cost of providing additional ships and other equipments. All that money is spent in this country, and it simply takes the shape of accelerating and encouraging our first national industry—the building of ships."

From the foregoing, it will be seen that the United States are in earnest in the intention of resuming their position as a naval power. It is, however, somewhat significant that at present all this construction seems to tend in the direction of vessels more fitted to run away from an antagonist of real weight than to sustain the glorious tradition of the American sea service. With but one or two exceptions, these ships are better prepared to destroy commerce than to protect it. There is no sign of a fleet fitted to cope with European armor-clads if they crossed the Atlantic as they have done before. After all, though, it is better to crawl before trying to run, and we may yet see designed, laid down and built by native talent in a United States Navy-yard that crux of naval construction, the "battle-ship of the future."

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

CHEMISTRY APPLIED TO RAILROADS.*

I. WHAT THE CHEMIST DOES.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(Copyright, 1889, by C. B. Dudley and F. N. Pease.)

The question has often been asked what a chemist can have to do on a railroad, and the query is a very natural one. Those whose ideas of modern railroads are based on what they see when a train passes by, have very little conception of the infinite detail in the work required to produce this result. Those best informed in such matters, however, know that no phase of human effort in modern times makes demands on so many sources of knowledge, or utilizes under one general management, so many of the useful arts, as a modern railroad does. The relation between the Chemist and the movement of trains, and the carrying of passengers and freight, is not at all apparent at first sight. That chemistry plays no insignificant part in the final result, it is hoped will be made clear by what follows:

The reason why experts in any branch are employed by railroad companies, is found in the fact that there are constantly a large number of questions arising before railroad operating officers, which questions require for their solution, some knowledge of the laws of nature, and that the average operating officer is not generally fitted by training or acquired information, to obtain satisfactory answers from nature with reference to these questions, and even if he be so fitted, he has not the time to make experiments. Many such questions can be answered by the Civil Engineer or the Mechanical Engineer; many of them require for their answer, experiments in the domain of heat, light, or electricity, or physical tests, and some of them can only be answered by the Chemist. This has led to the employment of experts in two fields—namely, those who make physical experiments and tests, commonly called Engineers of Tests, and experts who make chemical experiments and tests, known as Chemists. It is interesting to note that during the last 15 years the recognized place of chemistry in the operation of railroads has grown to such an extent, that now no less than nine of the large railroad corporations of the country have a regularly employed Chemist. In some places this Chemist is also the Engineer of Tests, or, in other words, the general scientific expert, who makes both the physical as well as the chemical tests.

It is, perhaps, fair to say that when the question came up some 14 years ago of employing a chemist on the Pennsylvania Railroad, so little was the possible uses of such an expert appreciated, and so little work was known that he could do on a railroad, that permission to have a chemist was granted more as a concession and as an experiment than with any faith or belief that the scheme would prove to be permanent or valuable. It is also fair to say that at that time the field for work was as much unknown to the Chemist himself as to the railroad officers, and that for the first two or three years of the life of the laboratory, progress was necessarily very slow in consequence. It was not only necessary for him to have the chemical knowledge requisite to do the work when it was once in hand, but it was also necessary for the Chemist and officers both to study carefully the practical problems involved in railroad operation, and find the work for the laboratory to do. Chemists starting in on railroads at the present time, find a large amount of work ready for their hands, as the result of the work already done in this field, and it is not at all difficult now for one who has had two or three years' experience in one of the older railroad laboratories, to show marked results from his first or second year's work. It is, of course, clear that as the number of railroad chemists increase, they gradually expand the field, and necessarily give mutual help to each other, both by direct communication, and by the effects of their work on the manufacturers. The field is so large, however, that even though the number of chemists was increased four or fivefold, there would be, we think, no lack of new work for them to do for a number of years to come.

The Chemist having been secured, one of the first things that is usually given him, is to explain some peculiarity that has been observed in the service. The first work done after the laboratory of the Pennsylvania Railroad was established, was to make an investigation into the reason why the valves and steam cylinders corroded so badly. The ordinary life of a valve was about a year, and whenever an engine came in for repairs, there was always more or less corrosion about the seat where the steam-chest rests on the cylinder. A careful study was made of the conditions, and the conclusion reached was that the difficulty was due principally to the acids in the tallow used for lubricant, and that corrosion was assisted by the sponginess of the castings in the valves, since the cavities in the castings afforded places for the lodgment of the tallow. At the time this investigation was started, no record could be found in the literature of the case to show that the fat acids characteristic of tallow would corrode iron at the temperature of steam cylinders, and direct experiments were made with these acids demonstrating this point. The explanation of the difficulty having been obtained, of course attention was directed toward securing a mitigation of the trouble. The details of this subject will be presented later.

As another illustration of the application of chemistry to bad results obtained in service, the following may be cited: One of the special cars after having been cleaned by the car-cleaners was noticed to look badly, and on examination by the Foreman of Painters, it was declared that the varnish had nearly all been removed by the cleaning. As a matter of discipline, the Foreman Car-Cleaner was asked to explain why the varnish had been so badly used, and he claimed he could do no better with the soap he had. A sample of the soap used was submitted to the Chemist, who found not less than 3 per cent. of caustic soda, and 7 per cent. of carbonate of soda, in addition to the soda combined with the fat as legitimate soap. This, of course, explained the peculiarity and justified the foreman, as the soap solution used in washing the car was in reality a concentrated solution of sal soda and lye, which readily dissolves varnish.

Another field for the activity of the Chemist of a railroad is to protect against fraud. Not a few cases could be cited, showing attempts to sell at excessive prices, under some special name, common articles, which can be obtained in the market at very small figures. One of the most common of these attempts is that of selling some cheap materials for use as anti-incrustating boiler compounds. Dry material has been offered at 25 cents per lb., which on examination has been found to be nothing but sawdust and sal soda. Again, boiler compounds have been offered at 50 cents per gallon, which have been found to be apparently spent tan liquor, containing a little sal soda, 95 per cent. of the material being water simply. A very common field, likewise, is the one of alloys. Some composition of metal, which can be made at a slight excess over the cost of the metals entering into it, is offered under a special name, at two or three times the cost of the ingredients. Disinfectants are likewise another special field for imposition. Ordinary sulphate of iron, or copperas, which can be purchased in the market at 90 cents per 100 lbs., has been offered under some high-sounding name at 10, 15, or 20 cents per lb. This list could be enlarged to almost any extent. One of the most recent instances which has come to our notice is that of a material to protect iron from rusting, which was offered under a special name at from 15 to 25 cents per lb. On examination it proved to be nothing more than ordinary 500° fire-test petroleum, known in the market as cylinder stock, and which can be bought at from 1½ to 2 cents per lb. by the 100 barrels, if required. That the material is

* This is the first of a series of articles relating to various subjects connected with the operation of railroads, upon which more or less definite information has been obtained in the Motive Power Department of the Pennsylvania Railroad during the last 15 years. They are contributed by permission of Mr. Theodore N. Ely, General Superintendent of Motive Power of that line, and the earlier articles will be devoted more especially to Railroad Supplies.

efficient and good for the purpose, is common knowledge, and it is difficult to see how any one could offer such material for sale at the price above mentioned, and call it legitimate business.

Another line of activity of the Chemist is to prove whether the assertions made by commercial men are true or false. It is common experience with railroad officers, especially Purchasing Agents, to meet men having materials for sale, for which they claim most extraordinary results. Houses engaged in legitimate trade claim for their products much better results than those obtained from the goods of their rivals, and between the representations of different firms of equally good standing, the Purchasing Agent, who is anxious to get the best thing, is often sorely puzzled. Almost the whole realm of supplies used by railroads is subject to this peculiarity, and it is difficult to pick out examples. Possibly paints, oils, and greases, are most commonly misrepresented in this way. The statements made by the men anxious to sell are often not only absurd, but laughable in the extreme to persons who are well informed. The representative of a certain grease offered for general lubrication, recently called upon us, to set forth the merits of his wares. In the course of the conversation with him, it was remarked that the usual difficulty with regard to greases, and the cups which were usually used for feeding them, was that, upon the journal getting a little warm, the grease would melt and all run out, leaving the journal without any lubricant whatever, the ordinary control over the feed in the case of grease being obviously inapplicable. To this statement the representative of the grease, with the utmost coolness, and with the evident expectation of being believed remarked that "This grease is entirely unaffected by changes of temperature." Upon our offering to place an order with him for three 10-lb. cans of the grease, to be put in as many museums, and labeled as "The only substance in nature not affected by temperature," he saw the absurdity of his position, and as gracefully as possible modified his statement to one that the material was *only a little* affected by temperature.

Again, not infrequently, parties anxious to sell represent their materials as being first-class in every respect, or in accordance to the specifications then in force. Often this is misrepresentation, and many times parties are perfectly honest and believe what they say, being simply misinformed themselves about their own goods. In either case, if a trial order is placed with them and a shipment made, difficulty often arises in the service, and too late it is found that the material is inferior. To such an extent is this the case, that at present it is quite the custom when a new party desires to furnish materials for the use of the Pennsylvania Railroad, to require him to send a sample of his material for examination before the Purchasing Agent feels willing to place an order with him. The saving in annoyance and vexatious disputes by this method is no small relief, not only to the Purchasing Department, but also to those who have to use the materials.

INTERIOR OF PENNSYLVANIA RAILROAD LABORATORY AT ALTOONA.

It is not, of course, claimed that chemical verification of the statements of commercial men, is the only method open to the puzzled railroad officer. Often his practical men can make tests sufficiently accurate to decide many of the questions, but no small number of assertions can only be checked up in a chemical way, although it should be fairly confessed that time and the whole resources of our chemical knowledge frequently fail to put a quietus on the misrepresentations of those who are anxious to sell.

Another field of activity for a good chemist on a railroad is to make investigations, to guide the practices of the road, and the expenditures of money. One or two illustrations will probably make this point clear. It is well known that natural waters, as they occur along the line of a road, must necessarily be used in the boilers for steam generation. It is also well known by those who are at all familiar with the subject, that waters differ very widely from each other in their value for steam purposes. Almost all waters contain more or less mineral matter dissolved in the water, which, when the water is boiled away, is left behind as a hard residue in the boiler, commonly known as boiler scale, and the waters that must be used vary from, perhaps, three grains to the gallon, up to as high as 40 or 50 grains per gallon of scale-making material. It has for quite a long time been the practice of the Pennsylvania Railroad to establish no new water stations until all the sources of water supply in that region have been examined as to the scale-making properties of the waters, and it is known that much good has resulted from this examination. Oft-times an expenditure of a number of thousand dollars, and the establishing of a poor water station, is avoided by so simple a thing as the determination of the total solid residue left on evaporating a sample of the water. The saving in boiler repairs and coal resulting from only using the best water accessible, is hardly capable of calculation, but those who are best informed on the subject will not hesitate to assent to the statement, that it amounts to thousands of dollars per year on any railroad having as many as 100 locomotives.

Another example in this line will make the matter still more clear. Some four or five years ago, investigations were made in the laboratory of the Pennsylvania Railroad, on the composition of the oil burned in the hand lanterns and elsewhere, and known in railroad language as signal oil. This oil, as is doubtless well known, is a mixed oil, the principal constituents being either lard, colza, or mustard-seed oil, together with varying proportions of petroleum distillate, known in the market as 300° fire-test oil, and as head-light oil. The question to be decided was, What mixtures of these various oils will give satisfactory results at the least possible cost? To solve this problem analyses of various mixtures of signal oil obtainable in the market were made, and then new mixtures were made in various proportions of the oils mentioned above, which were subjected to burning tests. As a result of the whole work, which extended over a period of a month or two, a formula was developed which gave an oil that was perfectly satisfactory by all tests, and at the same time produced a saving at the prices then prevalent of about 10 cents per gallon over the practice then in use. Oil was made according to this formula, and distributed to the men without their knowledge that any change had been made, and quite to the gratification of those authorizing the change, and somewhat to their astonishment, no increase of complaints in regard to oil could be observed. The economy in operating expenses produced by this change amounted to about $15,000 per year.

In addition to the examination of water for boiler use, a chemist on a railroad is not infrequently called upon to examine water for drinking purposes, both in a chemical and hygienic way. The money results of such an examination can hardly be stated, since to say nothing about the direct losses due to sickness and disease, it is, of course, impossible to calculate the detriment to the service due to inefficiency arising from a semi-invalid body.

Still another class of work where a railroad chemist has a chance to exert himself, is found in the testing of new devices offered as possible improvements in the present practices of railroads. A very good example of this are the experiments made on the ventilation of cars some eight or ten years ago, under the direction of the Chemist and the Engineer of Tests of the Pennsylvania Railroad. A new system of car ventilation having the name of the inventor had been developed and put on a single car. The money of a number of "promoters" was invested to the extent of fitting up this car, and the possibilities of a large company to push the matter, and bring the system into general use on railroads, was in prospect. This car was turned over to the two experts, with instructions to devise and make such experiments as would demonstrate whether the new system had any points of superiority over the one at that time in use. Without going minutely into detail, experiments were made on the relative capacity of the two systems to exclude objectionable matter, especially dust and cinders. Various experiments were also made on the capability of the two systems for removing objectionable matter formed within the car. These experiments embraced the relative length of time under normal conditions, that the two cars were freed from smoke and from odors generated in the car. Finally, the two cars were loaded in accordance with their capacity with men from the shops, and a run made, the ventilation being entirely a function of the characteristics of the two systems—that is, no doors or windows were left open. Samples of air were taken from the cars toward the end of the run, and also while standing on the tracks, without opening the doors or windows, to see what the ventilation was when standing still. These samples of air were duly analyzed for carbonic acid, that gas being, as is well known, thrown off by the lungs and body of every person. The results of the tests showed that while the two cars were running, the air in the new car contained from 0.50 to 0.60 per cent. of carbonic acid, while the car fitted with the old system contained from 0.20 to 0.30 per cent. While standing still the old car contained 0.55 per cent. of carbonic acid, and the new car ran up to something over 3 per cent. As the amount of carbonic acid allowable in the air for health, as stated by the best hygienic authorities, is not over 0.10 or 0.15 per cent., it was evident that not only the standard car in use needed attention as to ventilation, but also that the new car offered in competition had no points of superiority sufficient to recommend its adoption. It is, perhaps, needless to say that this investigation produced a complete collapse of the new car-ventilating company. It may be added for information, that analyses of air from cars made under the direction of the State Board of Health of Massachusetts, confirm the analyses of the Pennsylvania Railroad car, as given above; and that it seems probable the average of the air in cars throughout the country during the winter season, at least, is about one-half as good as it should be. In other words, since the ventilation of cars, as elsewhere, consists of taking fresh air into the car and foul air out, one-half as much air per hour is taken into cars in the United States in general, as should be for health, at least, during the winter season.

Perhaps the most important work of the Chemist on a railroad is the investigation in regard to the materials or supplies used, and the examination of shipments to see whether they are what they profess to be. The usual method pursued on the Pennsylvania Railroad is something as follows: Some difficulty arises in the service; the case is investigated, and the cause of the difficulty ascertained. If this difficulty is due to something characteristic of the practice of the road, usually a circular of instruction to the men is prepared, explaining the difficulty, and how to avoid it. A number of such circulars of instruction have already been prepared and issued to the men, with very gratifying results.

If, on the other hand, the difficulty is found to lie in the material or supplies furnished, a careful study of the special material at fault is made. This study may take a year or two before satisfactory conclusions are reached, but ultimately the results of the study are embodied in what are known as "specifications" in printed form, a copy of which specifications accompanies each order for that kind of material. The finding out what substances give the best results in service, or the making of specifications, is not at all an insignificant matter. It involves an intimate knowledge of all the requirements of the material from a railroad standpoint, and an intimate knowledge of all the processes leading up to the commercial product which is in question. Obviously, if the specifications do not give a material which proves satisfactory in service, or if the specifications demand more than the manufacturers can give, they are worthless. During the nearly 14 years' existence of the Pennsylvania Railroad Laboratory, chemical specifications for only about 25 different commercial products have been prepared. In later articles of this series an attempt will be made to give the reasons

why, and a complete explanation of the specifications which have been prepared.

The preparation of the specifications, although a necessary preliminary, is only a small portion of the most important work of a railroad chemist. As long as competition in business is as severe as it is at present, there will be constant temptation on the part of the manufacturers to furnish inferior materials, even though the material is bought on specifications, and here comes the most voluminous work of the chemist—namely, the examination of samples taken from shipments, to see whether they fill requirements. In the Pennsylvania Railroad Laboratory, at the present time, four chemists are engaged on this work the largest portion of each working day. Samples from some 4,000 shipments per year are examined, the average number of determinations per sample being about five. This work, in addition to the examination of miscellaneous samples of material, either for investigation, or to settle some point connected with the service, makes the total number of determinations made in the Pennsylvania Railroad Laboratory somewhere between 25,000 and 30,000 per year.

It will, of course, be understood that the 25 specifications already issued cover only a small portion of the field. The number of kinds of material that do not yet have specifications is large, and the laboratory is constantly expanding in this direction, no less than three or four new specifications being under consideration at the present time.

It sometimes happens that after a subject has been investigated, and satisfactory conclusions reached in regard to the material desired, the obtaining of this material in the market is not easy, or, if it can be obtained, it is only at a high rate. So many difficulties of this kind have occurred, that, in connection with the laboratory, a manufacturing establishment has been started, which already makes a number of articles for the use of the road, notably disinfectant, polishing compound, blue-print solution, battery solutions, etc. It seems probable that this line will necessarily increase, for reasons that will be subsequently stated.

The query will naturally arise in the mind of every railroad man, whether specifying the quality of material does not necessarily increase the price, and, therefore, whether, after all, there is any real advantage in specifications. It is gratifying to be able to state that the experience of the Pennsylvania Railroad, for now nearly 14 years, is in general, that the price is not seriously affected either way by the preparation of specifications. Indeed, in many cases materials on specifications are obtained at lower rates than prevailed before the specifications were issued. The principal reasons for this seem to be, first, that manufacturers, knowing what is going to be used, can provide themselves with the raw materials in larger quantity, and thus get the benefit of reduced rates, and second, all manufacturers in the same line being required to bid on the same requirements, naturally bring their price just as low as it is possible to get it, in order to be sure of getting the business. Whatever the cause, the fact remains.

There is another gratifying result which follows the work of a good chemist on a railroad—and, indeed, the same may be said of any expert work—and that is, if the Chemist, Engineer of Tests, or other expert, is conscientious and competent, and carries his investigations on until he has obtained a complete explanation or solution of the problem in hand, based on some law of nature, the subsequent action taken by the railroad officers in accordance with the results of this investigation is so much more intelligently done, that it is quite apt to be permanent. Many questions have been put at rest, and many standard practices adopted on the Pennsylvania Railroad during the last 14 years, as the result of the studies and investigations of the various experts employed, and many of the problems studied during this time have been so well settled by the investigations made, that few questions in regard to them have subsequently arisen. There are few railroad operating officers, who will not appreciate the freedom from annoyance which results from the satisfactory solution of some knotty problem.

(TO BE CONTINUED.)

THE CAIRO BRIDGE.

THIS notable structure, one of the longest—if not the longest—truss bridges in the world, crosses the Ohio River just above its junction with the Mississippi, at a point where the crossing has heretofore been made by steam ferries, and where, until the recent great development of long-span construction, it was not deemed possible to build a bridge which would not be too serious an obstruction to navigation to be permitted. It connects permanently the Main Line and the Southern Division of the Illinois Central Railroad, the exchange of traffic between those sections of the Chicago-New Orleans Line having increased to a degree which warranted the Company in expending the large amount—some $2,500,000—required to build the bridge.

The bridge has no draw-span, being a high-level bridge placed at such an elevation as to permit the river steamers to pass under it without interference. There are 12 spans in the bridge proper, and 40 shorter spans in the approaches, making its total length a few feet over two miles.

As just stated, the bridge proper over the main river consists of 12 spans resting on masonry piers. Two of these on the northern end and one on the southern end are supported by pile foundations; the others are built upon caissons. These caissons were all sunk 75 ft. below the low-water level, and rest upon the bottom at that depth, which is very hard clay or compact sand. They were built of squared timber—Southern pine—bolted together, sheathed and caulked outside. They were filled with concrete after they were sunk to their places; three of them, carrying the piers for the long channel spans, are 30 ft. wide, 70 ft. long, and 16 ft. high, the crib on top being 34 ft. high; the others are 26 ft. wide, 60 ft. long, and 16 ft. high.

The level of the lower chord of the bridge is 102 ft. above low water, and the piers are consequently about 127 ft. in height from the top of the crib.

The arrangement of the spans of the main bridge is as follows, beginning on the northern or Illinois side of the river: Two spans of 257 ft. each; two spans of 523 ft. 6 in. each; one span of 406 ft.; six spans of 405 ft. each; one span of 255 ft. The lengths given for the spans are over all, the distance between the centers of the end pins being about 5 ft. less. They are all through spans and are double-intersection trusses, with the upper and lower chords parallel, except the 255-ft. and 257-ft. spans, which are deck-spans with single intersection. The trusses of the two longer spans are 60 ft. 9½ in. deep between centers of pins, and the 405-ft. and 406-ft. spans are 50 ft. in depth. The 255-ft. and 257-ft. spans are 26 ft. in depth. The entire superstructure is of steel.

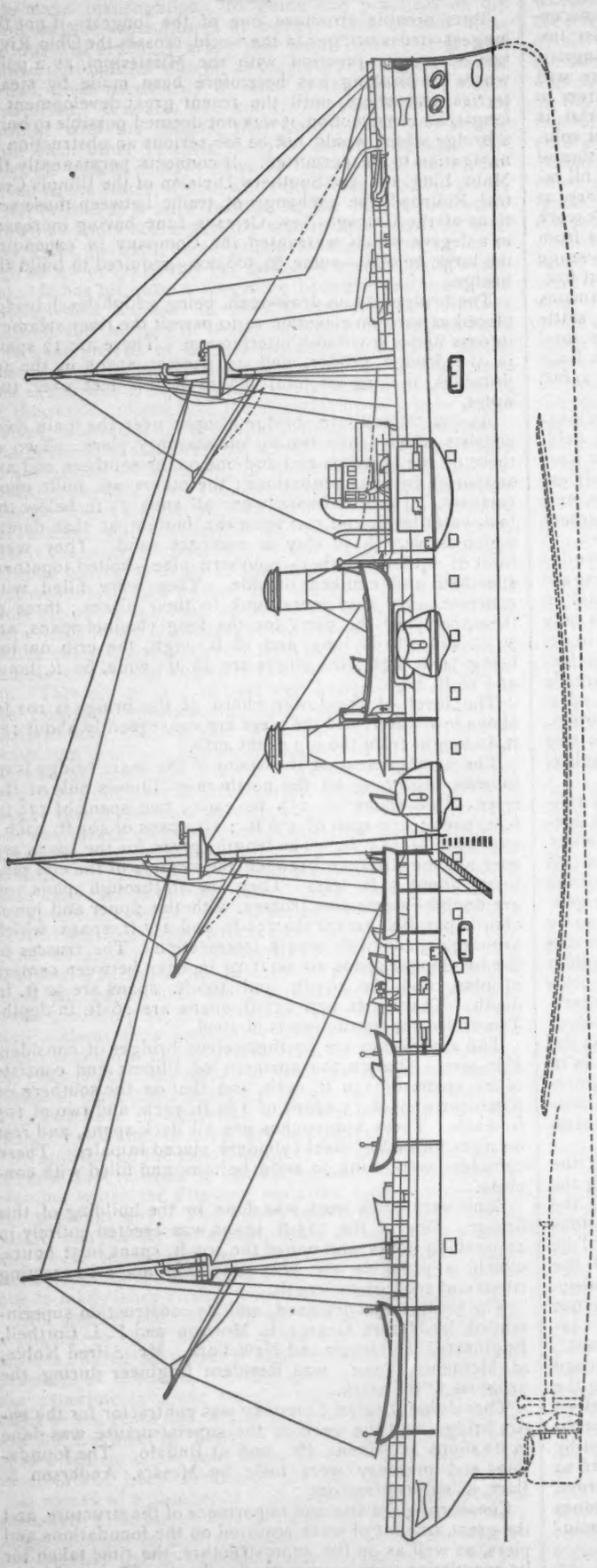
The approaches are by themselves bridges of considerable size. That on the northern or Illinois end consists of 25 spans of 150 ft. each, and that on the southern or Kentucky end of 13 spans of 150 ft. each, and two of 105 ft. each. These approaches are all deck-spans, and rest on piers formed of steel cylinders placed in pairs. These cylinders were sunk to solid bottom, and filled with concrete.

Some very quick work was done in the building of this bridge. One of the 523-ft. spans was erected entirely in 45 working hours, and one of the 405-ft. spans in 31 hours, which is probably the best time ever made in erecting trusses of such great length.

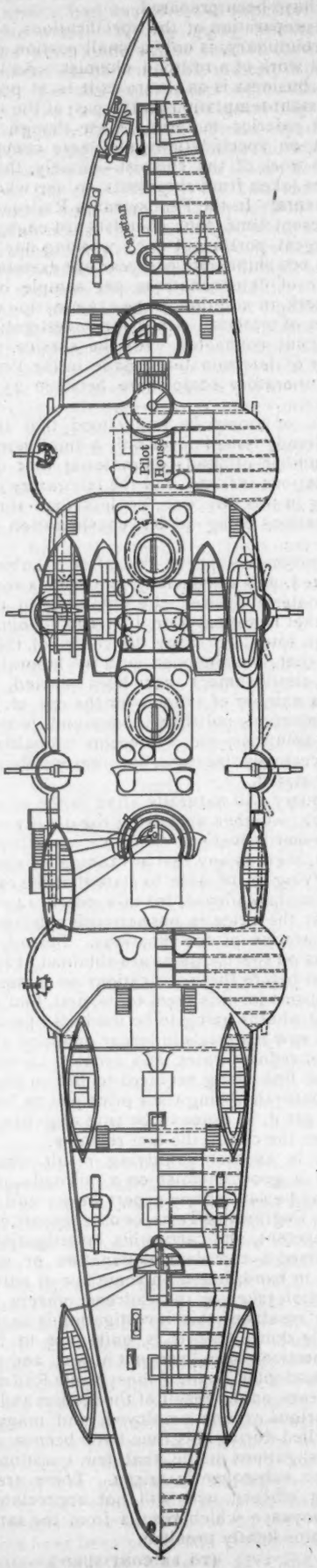
The bridge was designed, and its construction superintended, by Messrs. George L. Morison and E. L. Corthell, Engineers, of Chicago and New York. Mr. Alfred Noble, of Memphis, Tenn., was Resident Engineer during the progress of the work.

The Union Bridge Company was contractor for the entire bridge, and the work on the superstructure was done in its shops at Athens, Pa., and at Buffalo. The foundations and masonry were built by Messrs. Anderson & Barr, as sub-contractors.

Considering the size and importance of the structure, and the great amount of work required on the foundations and piers, as well as on the superstructure, the time taken for its completion was comparatively short. The work was



ELEVATION.



PLAN OF POOP DECK.

CRUISER "SAN FRANCISCO," FOR THE UNITED STATES NAVY.

BUILT BY THE UNION IRON WORKS, SAN FRANCISCO.

begun in August, 1888, and was completed on October 29 last, the whole time taken being thus a little over 14 months.

The Cairo Bridge, as will be seen from this brief description, is entitled to be considered one of the great bridges of the world, and a notable example of American design and construction.

UNITED STATES NAVAL PROGRESS.

UNDER the second call for bids for the 2,000-ton cruisers authorized by the act of September, 1888, five bids were received at the Navy Department. All the bids were of Class I, hull and machinery to be built according to the plans and specifications furnished by the Department. These bids were as follows:

1. Union Iron Works, San Francisco, for one vessel, $775,000; for two vessels, $1,450,000; for all the three, $2,054,001.
2. N. F. Palmer, Jr., & Company for one vessel, $674,000.
3. Columbian Iron Works, Baltimore, for one cruiser, $625,000; for two cruisers, $1,225,000.
4. Bath Iron Works, Bath, Me., for one, two or three cruisers at $675,000 each.
5. Harrison Loring, Boston, for one cruiser, $674,000.

The contract for two of the ships was awarded to the Columbian Iron Works, Baltimore, at their bid of $1,225,000, which was the lowest received. These works have just completed the gun-boat *Petrel*; the two new vessels will thus be built in their yard in Baltimore.

For the third vessel the bids of Palmer & Company and of Mr. Loring were the same, and by agreement between them, the Palmer bid was withdrawn and the contract awarded to Harrison Loring, of Boston, for $674,000. It is understood that he will build the ship, and that the engines will be built by Palmer & Company. The last-named firm are now building the *Concord* and the *Bennington*, the two gun-boats which are nearly completed, and the engines of the armored ship *Maine*, the hull of which is under construction at the Brooklyn Navy Yard.

These 2,000-ton cruisers were described and illustrated in the JOURNAL for July last, page 302. It is sufficient to say that they will be protected cruisers 257 ft. long, 37 ft. in breadth, 19 ft. 6 in. in depth and 14 ft. 6 in. draft. They will have two triple-expansion engines with cylinders 26½ in., 39 in. and 63 in. in diameter and 33 in. stroke. They will carry two 6-in. and eight 4-in. rapid-fire guns, with a number of smaller guns. The original specifications called for a speed of 18 knots, but the bids received under these did not come within the limit of the cost fixed by Congress and new specifications were issued, fixing the speed at 17 knots an hour. The contracts now awarded are, of course, under the amended specifications.

LAUNCH OF THE "SAN FRANCISCO."

The *San Francisco* was successfully launched from a yard of the Union Iron Works in San Francisco, October 26. This ship is the second one built for the Government in that yard, the *Charleston* having been the first. The contract was let in July, 1887, the construction of the vessel having been authorized by the act of March, 1887. This ship and the *Philadelphia*, which is building at the Cramp Yards in Philadelphia, are sister ships, and the contracts were let at the same time, the price for the *Philadelphia* being $1,350,000 and for the *San Francisco*, $1,428,000. This ship is a twin-screw cruiser 328 ft. long over all; 310 ft. on water line; 49½ ft. in breadth; 31 ft. 8 in. depth; 18 ft. mean draft, and her displacement when completed will be about 4,100 tons. The vessel is not armored, but carries a heavy protective deck just above the water line, and the machinery is further protected by the arrangement of the coal-bunkers. The engines are triple-expansion, with cylinders 42 in., 60 in. and 94 in. in diameter and 42 in. stroke. The boilers, 15 ft. diameter, will carry a working pressure of 135 lbs. The two screws are three-bladed and 14½ ft. in diameter. The engines are expected to develop 7,500 H.P. under natural draft and 9,000 H. P. under forced draft, and the maximum speed is to be 19 knots an hour. The armament is to consist of 12 6-in. guns, with a secondary battery of small rapid-fire and machine guns.

In this connection we have reproduced the accompanying illustration—first published in the JOURNAL for July, 1887—which gives a side elevation and deck plan of the designs for this ship as prepared in the Navy Department, according to which she has been built. The *San Francisco*, the *Philadelphia*, and the *Newark* are the largest cruisers yet built for the Navy, but will be exceeded in weight, fighting power, and strength of armor by the *Maine*, the *Texas*, and the new battle-ship for which designs are now being prepared in the Navy Department.

THE LEAGUE ISLAND NAVY YARD.

The board appointed in July last to report a plan for the development of the League Island Navy Yard in the Delaware River has submitted its report. The report states that the island has an area of 923 acres, abundantly sufficient for any purpose required. It has a further great advantage that, being situated in the Delaware River, 90 miles from the sea, the salt water does not reach it, and that, while there is a variation of about 6 ft. in the tide, the water is always fresh. Moreover, it is or can be made practically beyond the reach of attack from a foreign navy.

The Board recommends that this yard should be provided with all the facilities and plans for building, equipping, and repairing naval vessels, and also considered that it is well placed for the establishment of works for constructing guns of largest size. It is so placed that supplies of all sorts, coal and iron, can be cheaply and quickly obtained and delivered at the yard. The main improvements proposed are as follows:

1. Converting a portion of the back channel into a deep and spacious reserved basin.
2. Constructing a smaller basin for building and repairs, opening into the reserved basin and also communicating with the Delaware by a channel.
3. Locating dry-docks and building slips within the two basins, with plate and bending shops conveniently placed.
4. Concentrating all the other shops and structures in the central space adjoining the smaller basin and dry-docks.
5. Building a permanent retaining wall along the entire river front.

The total basin area proposed is 156 acres. The estimate given by the Board includes the building of graving docks for constructing large vessels. The yard on these plans, the Board says, will be equal to the largest of foreign dock-yards, and will have a capacity for work greater than that of all the other navy yards combined. There will be, of course, should the plans be carried out, a hospital, barracks, foundry, storage yard for torpedo-boats, ropewalk, etc.

The total estimate for the complete development of the yard on this plan is $14,565,480. Of this amount $5,274,155 is required for the work to be first undertaken, the basins and docks. It is recommended that the appropriation for the first year be $1,596,000, which will give means for a proper beginning of the work on a large scale.

What action the Secretary of the Navy will take on this report is not known, and, of course, nothing can be done until Congress makes an appropriation.

THE WASHINGTON GUN FACTORY.

The gun factory at the Washington Navy-yard is now working to its full capacity, and the machinery which was ordered some time ago is being set up as fast as received, but until it is all in place the work cannot be turned out as promptly as desired. The last guns shipped from the yard were the four 6-in. rifles for the new gunboat *Petrel*, and there are several more of the 6-in. guns nearly completed, including those for the *Bennington* and the *Concord*. Besides these guns, work is in progress on several 8-in. and 10-in. guns for the new vessels now building. Under the last appropriation of $600,000 made by Congress, a number of heavy tools were ordered, but these have not yet been delivered. Among the tools set up in the shops are some traveling cranes, the largest in the country, which were built by the Morgan Engineering Company, at Alliance, O., and some gun lathes of enor-

PLATE 61

C. & N.W. RY. STANDARD PILE BRIDGE

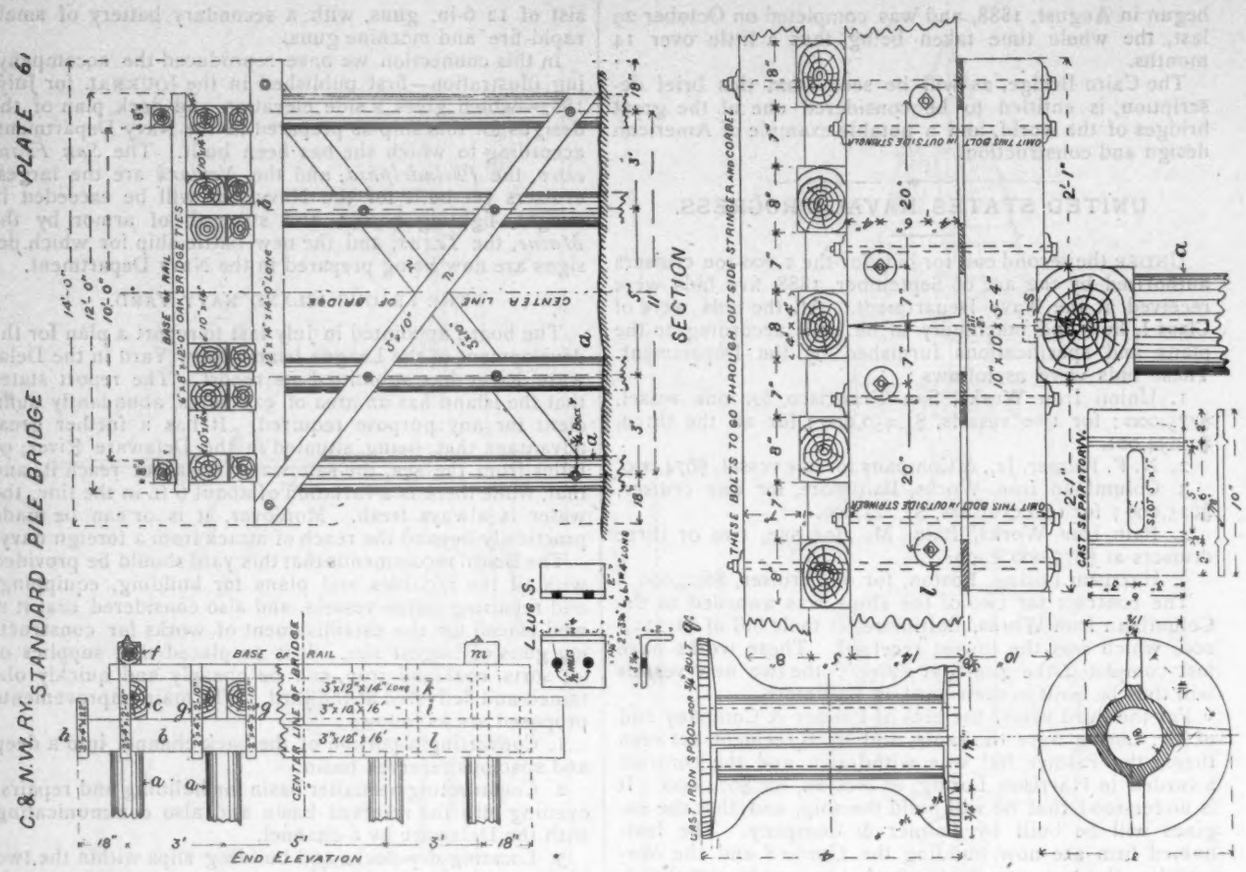
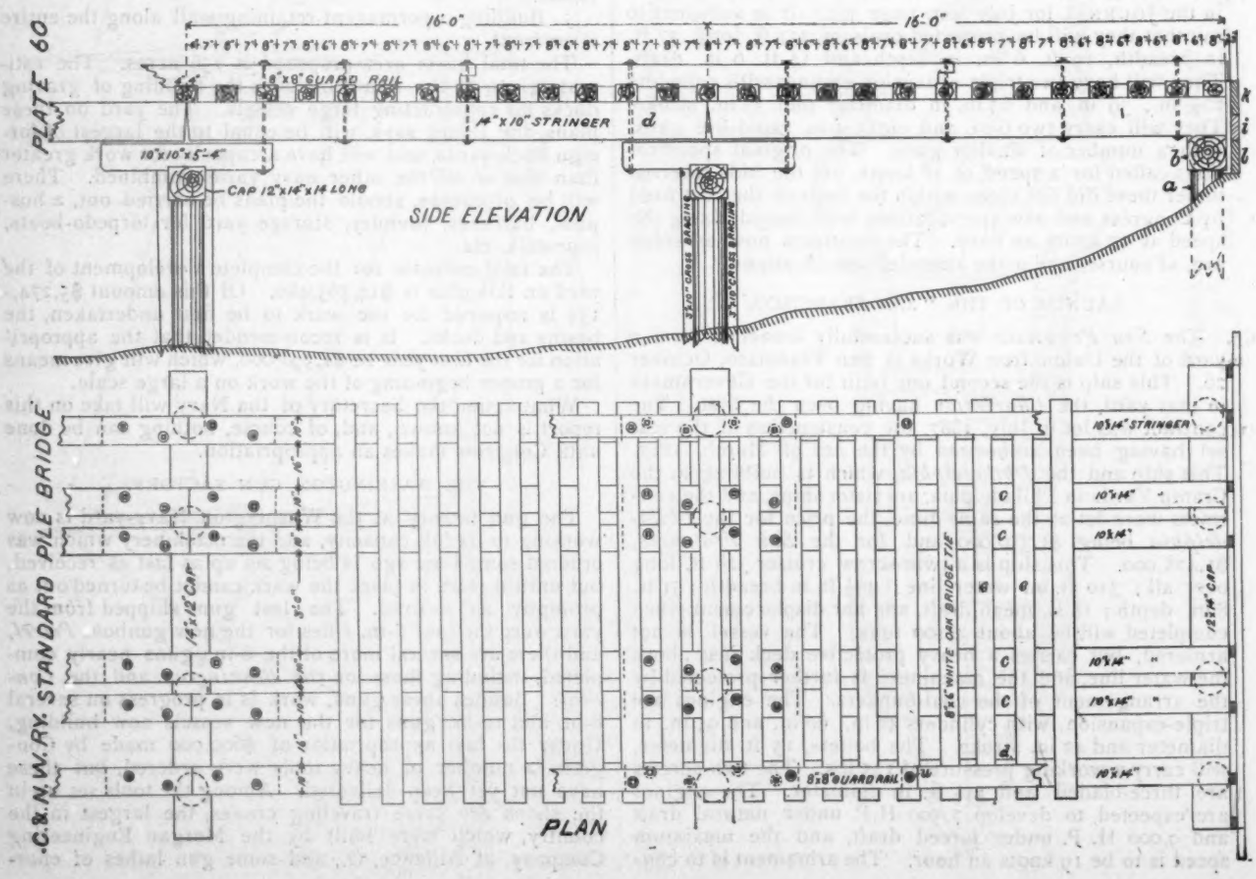


PLATE 60

C. & N.W. RY. STANDARD PILE BRIDGE



mous size. It is expected that forgings for two 12-in. guns, the largest yet made here, will shortly be received from the Bethlehem Iron Company, but the work upon these cannot be done until the lathe ordered especially for them is received. Besides the new guns all the work on the steel projectiles is done at this yard. The rough castings are supplied from the Bethlehem and the Midvale Works and finished in Washington.

THE NAVAL WAR COLLEGE.

The Board appointed some time ago to report upon the question of consolidating the several naval establishments at Newport, has submitted its report to the Secretary of War. The recommendation made is that the Torpedo Station, the War College and the Training Station be consolidated into one establishment, to be known as the Naval School of Application, and to be under the command of an officer of high rank. At this school officers should be instructed in Naval Strategy, Naval Logistics, the Use of Naval Weapons and Equipments, and such other branches as may prepare them for actual warfare. The Board believes that in order to conduct this school successfully as many vessels as possible should be associated with it, and attached to the station as practice vessels.

As to the course of study, the Board says that the proposed school would be divided naturally into four departments: The Art of War, the Torpedo Division, the Gunnery Division, and the Apprentice Training Division. Each of these divisions should be in charge of an officer of rank and experience. The school would be under the direct charge of the Bureau of Navigation. Such buildings as are required can be erected on the Government property on Goat Island from the appropriation made by Congress. The manufacturing part of the Torpedo Station should, however, be removed to some more suitable place, if possible, as in the present location it is very liable to attack and destruction in case of war.

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C. E.

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(*Continued from page 521.*)

CHAPTER XVIII.

WOODEN TRESTLE-WORK.

Originally, the word trestle was applied only to a movable frame, or set of legs connected at the top, and used for the purpose of supporting some superimposed weight. In this sense it is applied to all the different forms of frame-work used by carpenters for this purpose, such as supports for staging, trestle-horses, etc.

But in the sense in which it is used upon railroads, the word trestle has come to mean a number of legs connected at the top by a cross-piece, upon which rests a floor of sufficient strength to support the weight of passing trains. These trestles may be built of wood or iron, or a combination of both.

We will at present only consider those constructed of wood. The legs may be of any number, and cross-braced in some suitable manner to insure freedom from flexure.

A number of legs or posts connected by the same cross-piece or cap on top is called a "bent," as shown in Plate 63, Section No. 5. When these posts are framed into and rest upon a "sill" at the bottom, the bent is termed a "framed bent." In some cases the posts consist of piles driven firmly into the ground and connected at the top by a cap; such bents, to distinguish them, are called "pile bents," or pile bridges.

The use of wood in the form of trestles in railroad construction is pre-eminently an American practice. American engineers were the first to use it in this shape to any great extent, and although engineers of other nationalities have adopted wooden trestles where the environment and circumstances render them beyond a doubt desirable, still the difference in their use is just here; a French, English, or German engineer will in railroad construction never use wood in any form where it is in any way possible to procure metal or stone, and the enormous amount of expense he will incur to do away with wood in every way, is something entirely beyond the comprehension of the average American engineer. Our engineers, on the contrary, have, until the last few years, used wood in all railroad construction, where it was possible, and only used iron where it was unavoidable. This, of course, arose from the fact that iron was expensive and often difficult to procure, while wood was cheap and of most excellent quality.

Of late years, owing to the decrease in the cost of iron and steel, much less wood is used, and many wooden trestles and bridges are being replaced by iron ones. Notwithstanding this fact, however, wood in the form of culverts, trestles, and bridges is in very general use in railroad construction, and will so continue for a number of years.

This question of the use of wood in the form of trestles and bridges becomes of still greater importance to the railroad engineer from the fact that all the wooden structures put up on a road are usually designed and erected by the engineer in charge, while any elaborate piece of iron work is turned over to some expert upon the subject.

There are, of course, many evils and disadvantages connected with the use of wood in railroad construction. The two principal ones are:

1. Danger from fire.
2. Certainty of decay, involving at stated intervals complete renewals.

In the use of wood in culverts, as has been stated in Chapter V, these evils are reduced to a minimum. In box culverts the wood is buried deep in the ground, thus doing away with any danger from fire, and as, under most circumstances the wood is constantly wet, the rate of decay is very slow, and if the ordinary amount of watchfulness is used there can arise no element of danger. In time, however, the culvert must be renewed, and this renewal is generally made not in wood, but in some more durable material, such as stone-ware or iron pipes. The cost of this renewal is small compared with what the use of the same material would have been if used in the original construction, as all the facilities for transportation are present, and the whole cost is paid for out of the earnings of the road, and not by borrowed money, as is the case in the original construction.

Taking next open culverts, the disadvantages of the use of wood become more marked. They possess all the inherent evils of any opening in the track, without regard to the material used in spanning this opening. The drawbacks of these openings have already been described. Besides these there is danger from fire. The danger from decay is entirely preventable with proper care, and, therefore, will not be considered here, as it only involves a slight expense. The danger from fire, however, is one of grave importance, no matter how small or insignificant the opening may be, and also one against which the most careful watchfulness cannot secure immunity.

As we advance from open wooden culverts to trestles and bridges, the evils attending the use of wood increase also, and there is added to the danger to human life from the destruction of one of these structures, the loss and expense to the road due to the interruption of traffic caused by any break in the track that prevents the free circulation of trains.

These are, then, to repeat, the disadvantages attending the use of wood in the construction of culverts, trestles, and bridges:

1. Liability to destruction by fire, causing loss of life and interruption of traffic.
2. Certainty of decay, requiring never-ceasing watchfulness and a continual running expense for repairs and renewals.

The amount of importance that should be given to the first-mentioned evil depends upon the number of daily trains in use. The location of the structures in regard to the alignment is also to be considered—that is, culverts, trestles, or any openings in the track are much more ob-

PLATE 63

A. T. & S. F. R. R.

PILE & TRESTLE BRIDGES

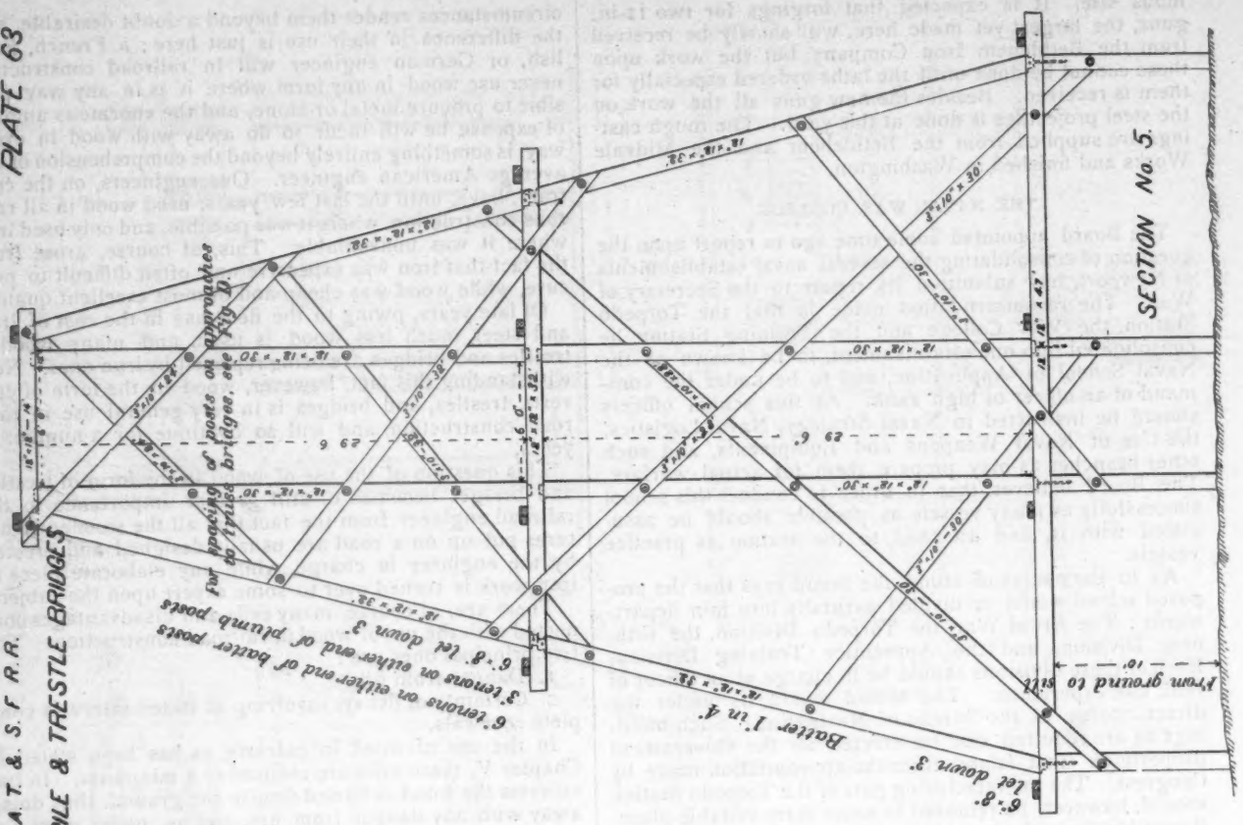
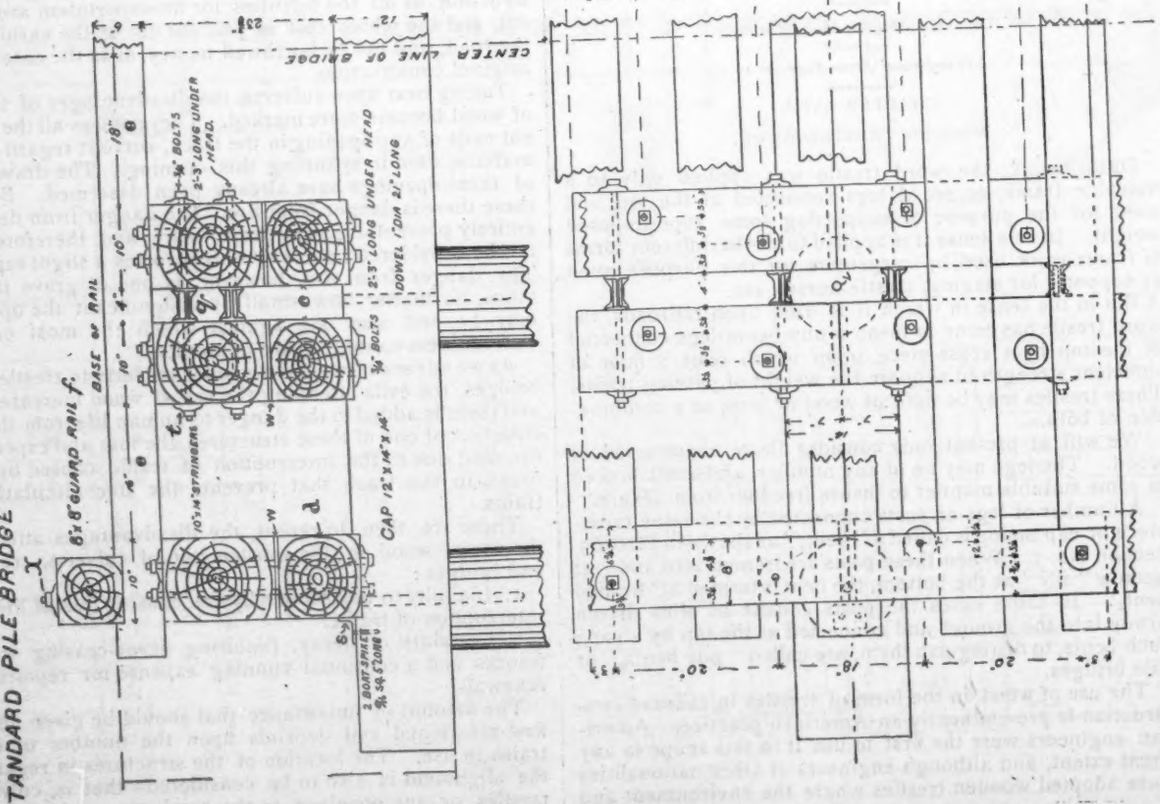

SECTION No. 5.
For spacing of posts on approaches to Trestle bridges, see Fig D.
6 tenons on either end of batter posts
3 tenons on either end of plumb posts
6"×8" let down 3.
Batter 1 in 4.
6"×8" let down 3.
From ground to sill.

PLATE 62

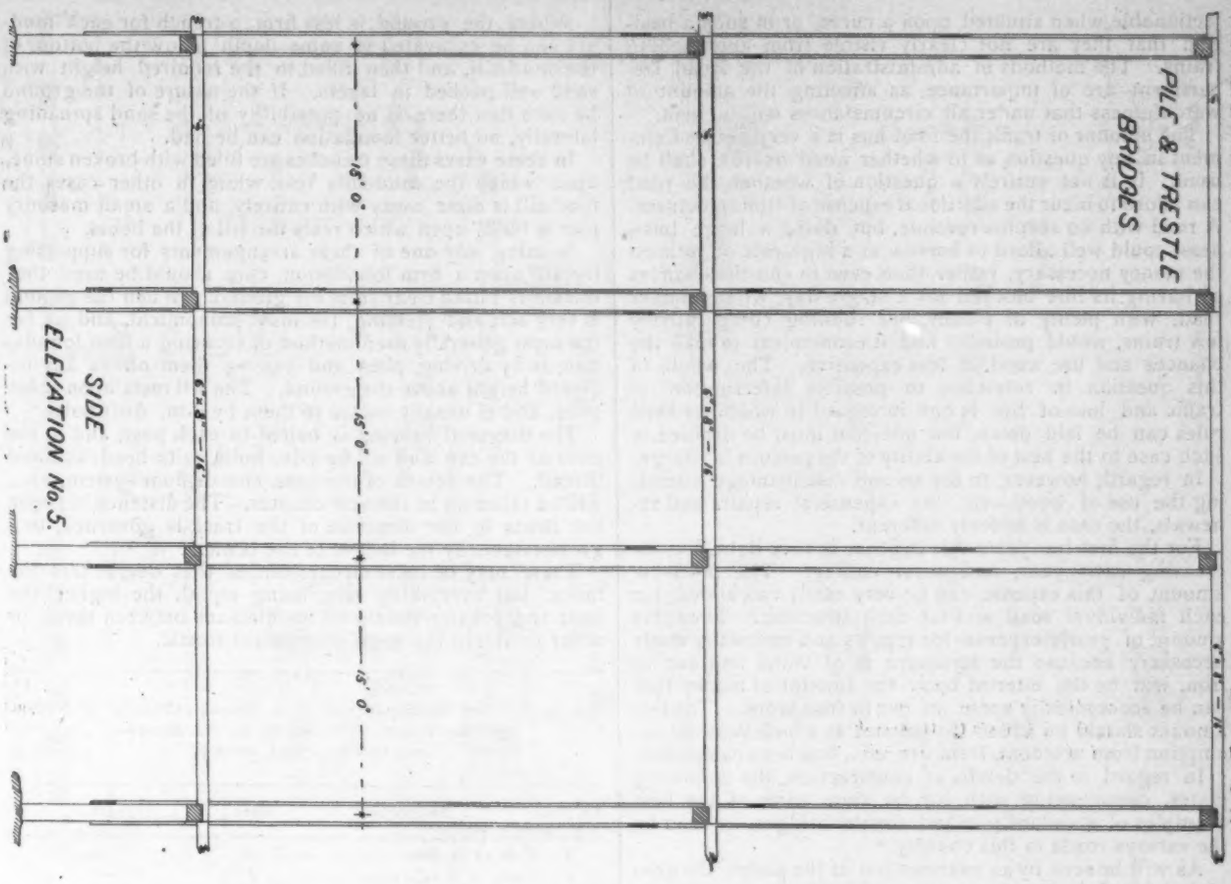


f. C.B.N.W.RY.

STANDARD PILE BRIDGE

A. T. & S. F. R. R.

PILE & TRESTLE BRIDGES

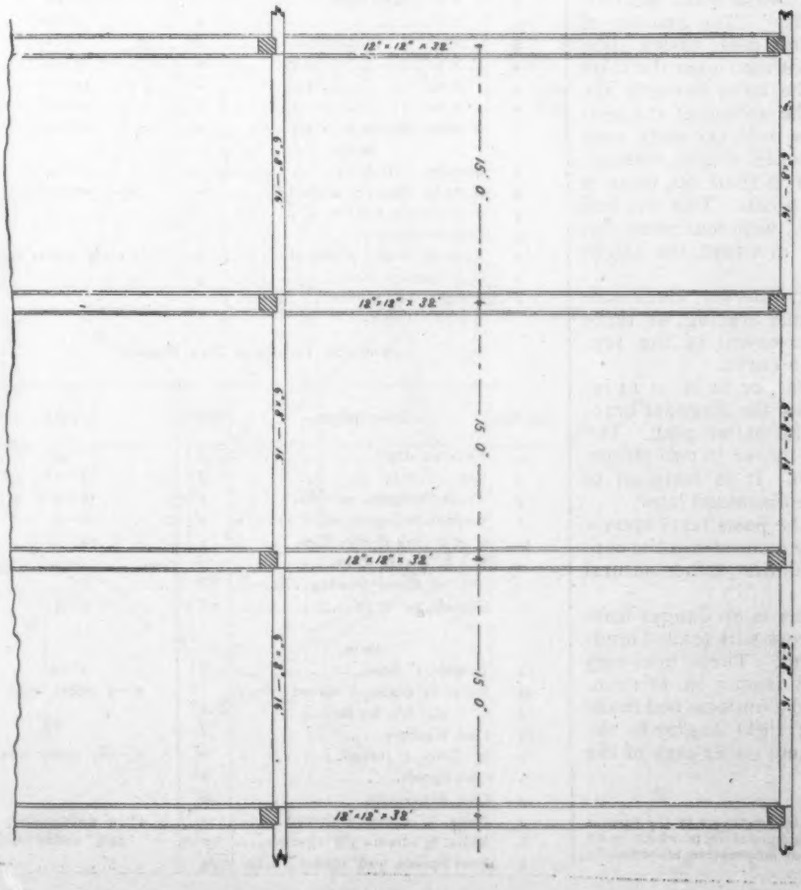


SIDE ELEVATION No. 5.

PLATE 64.

A. T. & S. F. R. R.

PILE & TRESTLE BRIDGES



SIDE ELEVATION No. 4

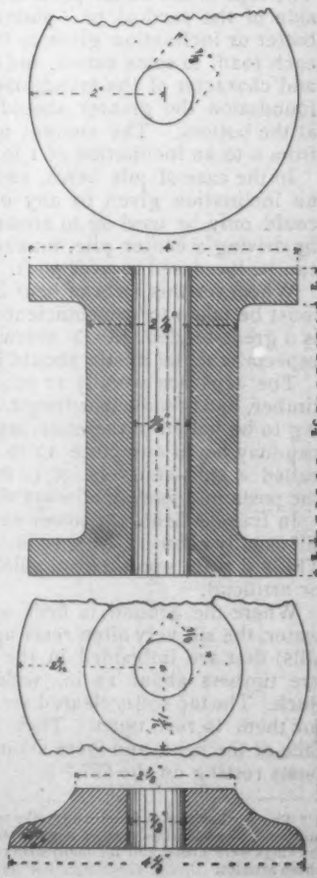


PLATE 65.

jectionable when situated upon a curve, or in such a position that they are not clearly visible from approaching trains. The methods of administration of the Road Department are of importance, as affecting the amount of watchfulness that under all circumstances will be kept.

The amount of traffic the road has is a very decided element in any question as to whether wood or iron shall be used. It is not entirely a question of whether the road can afford to incur the additional expense of iron structures. A road with no surplus revenue, but doing a large business, could well afford to borrow at a high rate of interest the money necessary, rather than even to run the chances of having its line blocked for a single day, while another road, with plenty of money, but running comparatively few trains, would probably find it economical to take the chances and use wood, if less expensive. The whole of this question in reference to possible interruption of traffic and loss of life is one in regard to which no fixed rules can be laid down, but one that must be decided in each case to the best of the ability of the persons in charge.

In regard, however, to the second disadvantage attending the use of wood—viz., the expense of repairs and renewals, the case is entirely different.

For the first few years this expense is very light, but increasing each year, and never ending. The probable amount of this expense can be very easily calculated for each individual road and for each structure. Then this amount of yearly expense for repairs and renewals, made necessary because the structure is of wood and not of iron, will be the interest upon the amount of money that can be economically spent to put in iron-work. To this amount should be added the amount at which possible exemption from accident, from fire, etc., has been calculated.

In regard to the details of construction, the following plates, commencing with No. 60, show some of the best examples of standard pile and trestle bridges, as used by the various roads in this country.*

As will be seen by an examination of the plates, the general plans of the bents are more or less the same, and consist of two vertical posts, one under each rail, and two batter posts, one on each side, as shown in the plates. The tops of the batter posts are from two to three feet outside of the vertical or "plumb posts." The amount of batter or inclination given to the batter posts varies upon each road, to some extent, and depends also upon the class and character of the foundation. The more unstable the foundation the greater should be the spread of the bent at the bottom. The amount used in ordinary work runs from 0 to an inclination of 1 in. horizontal to 4 in. vertical.

In the case of pile bents, as shown in Plate 66, there is no inclination given to any of the posts. This method could only be used up to about 24 ft., with four piles, but by driving a center pile, making five in a bent, the height can be increased to over 30 ft.

Whenever this form of bent is used, however, much care must be taken to use sufficient diagonal bracing, as there is a great tendency to a sidewise movement of the top, especially if the trestle should be on a curve.

The caps are usually 12 in. × 12 in., or 12 in. × 14 in. timber, and of sufficient length to allow the diagonal bracing to be bolted to the ends beyond the batter post. The cap may be in one piece 12 in. × 12 in., or in two pieces, called a split-cap, 6 in. × 12 in. each. It is fastened to the posts in a variety of ways that are discussed later.

In framed bents the lower end of the posts rests upon a sill usually about 12 in. × 12 in., or the same size as the cap. This sill rests upon a firm, solid foundation, either natural or artificial.

Where the ground is firm, and there is no danger from water, the sill very often rests upon cross-sills (called mud-sills) that are imbedded in the ground. These mud-sills are timbers about 12 in. wide, and from 4 in. to 12 in. thick. The top soil is cleared away, and a uniform bed made for them to rest upon. They run at right angles to the face of the bent, and there should be one under each of the posts resting on the sill.

* The Author wishes to return thanks to the Chief Engineers of the various railroads, to whose kindness he is indebted for blue-prints from which these drawings were made, and for many other points of information embodied in these articles.

Where the ground is less firm, a trench for each mud-sill can be excavated to some depth below the bottom of the mud-sill, and then filled to the required height with sand well packed in layers. If the nature of the ground be such that there is no possibility of the sand spreading laterally, no better foundation can be had.

In some cases these trenches are filled with broken stone, upon which the mud-sills rest, while in other cases the mud-sill is done away with entirely, and a small masonry pier is built, upon which rests the sill of the bents.

In using any one of these arrangements for supporting the sill upon a firm foundation, care should be used that the sill is raised clear from the ground. When the ground is very soft and yielding, the most economical, and by far the most generally used method of securing a firm foundation, is by driving piles and sawing them off at any required height above the ground. The sill rests upon these piles, and is usually bolted to them by ¾-in. drift-bolts.

The diagonal bracing is bolted to each post, and to the ends of the cap and sill by ¾-in. bolts, with head, nut and thread. The details of the caps, chords, floor system, etc., will be taken up in the next chapter. The distance between the bents in the direction of the track is governed, to a great extent, by the height of the bents.

There may be local circumstances that decide this distance, but everything else being equal, the higher the bent the greater should be the distance between them, in order to obtain the most economical trestle.

No. 34. Bill of Material for Pile Bridge, Chicago & Northwestern Railway.—Plates 60, 61, 62. Material for One-Span Pile Bridge.

No. Pcs.	Description.	Mark.	Length.
8	Piles, 12 in. diam.	*a*	
2	Caps, 12" × 14"	*b*	14'—0"
4	Track Stringers, 10" × 14"	*c*	16'—0"
2	Outside Stringers, 10" × 14"	*d*	16'—0"
14	6" × 8" Oak Bridge Ties	*e*	12'—0"
2	8" × 8" Guard Rails	*f*	16'—0"
12	2" × 4"	*g*	2'—10"
4	2" × 4"	*h*	1'—10"
2	3" × 10"	*i*	16'—0"
2	3" × 12"	*k*	14'—0"
2	3" × 12"	*l*	16'—0"
2	Number Boards, 8" × 1½".	*m*	1'—0"
	Iron.		
8	Dowels, 1" diam.	*v*	1'—9"
8	Bolts ¾" diam. 2" thread	*r*	2'—3" under head.
4	2" × 3¼ L's, 6.1 lbs.	*s*	4"
32	Cast Washers	*t*	
8	Bolts ¾" diam., 2" thread	*u*	2'—5¾" under head.
8	Cast Spools	*q*	
8	Pounds, 30 d Spikes		

Add for Two-Span Pile Bridge.

No. Pcs.	Description.	Mark.	Length.
4	Piles, 12" diam	*a*	
1	Cap, 12" × 14"	*b*	14'—0"
4	Track Stringers, 10" × 14"	*c*	16'—0"
2	Outside Stringers, 10" × 14"	*d*	16'—0"
13	6" × 8" Oak Bridge Ties	*e*	12'—0"
4	8" × 8" Guard Rails	*f*	9'—0"
2	3" × 10" Cross Bracing	*n*	
6	Corbels, 10" × 10"	*o*	5'—4"
	Iron.		
4	Dowels, 1" diam.	*v*	1'—9"
28	Bolts, ¾" diam., 2" thread	*r*	2'—3" under head.
2	2" × 3¼" L's, 6.1 lbs.	*s*	4"
88	Cast Washers	*t*	
4	¾" Bolts, 2" thread.	*u*	2'—5¾" under head.
8	Cast Spools	*q*	
24	Cast Separators.	*w*	
4	Bolts, ¾" diam., 2" thread	*x*	4'—2" under head.
8	Bolts, ¾" diam., 3½" thread	*y*	19¾" under head.
6	Boat Spikes, 5-16" square	*z*	5"

PLATE 67.

A. T. & S. F. R. R.

PILE & TRESTLE BRIDGES

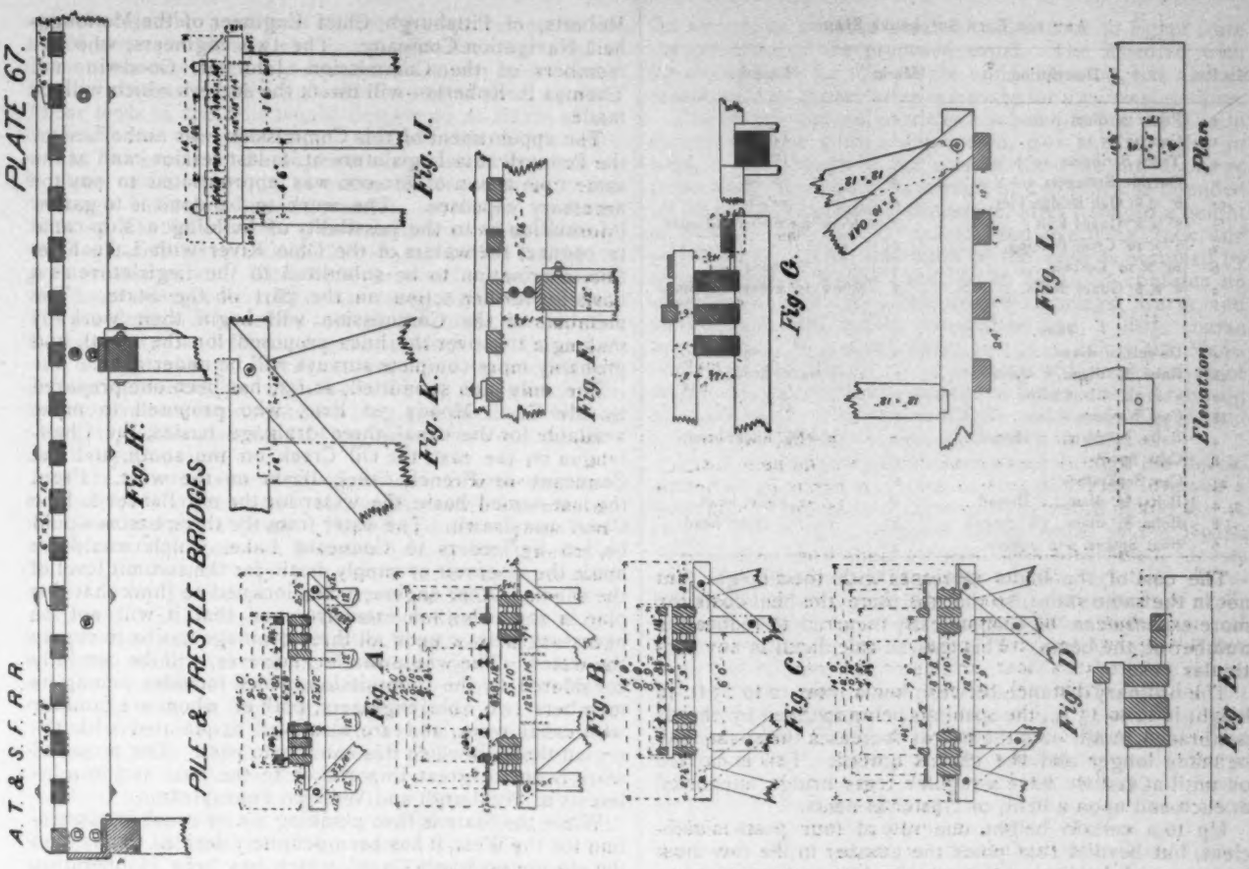
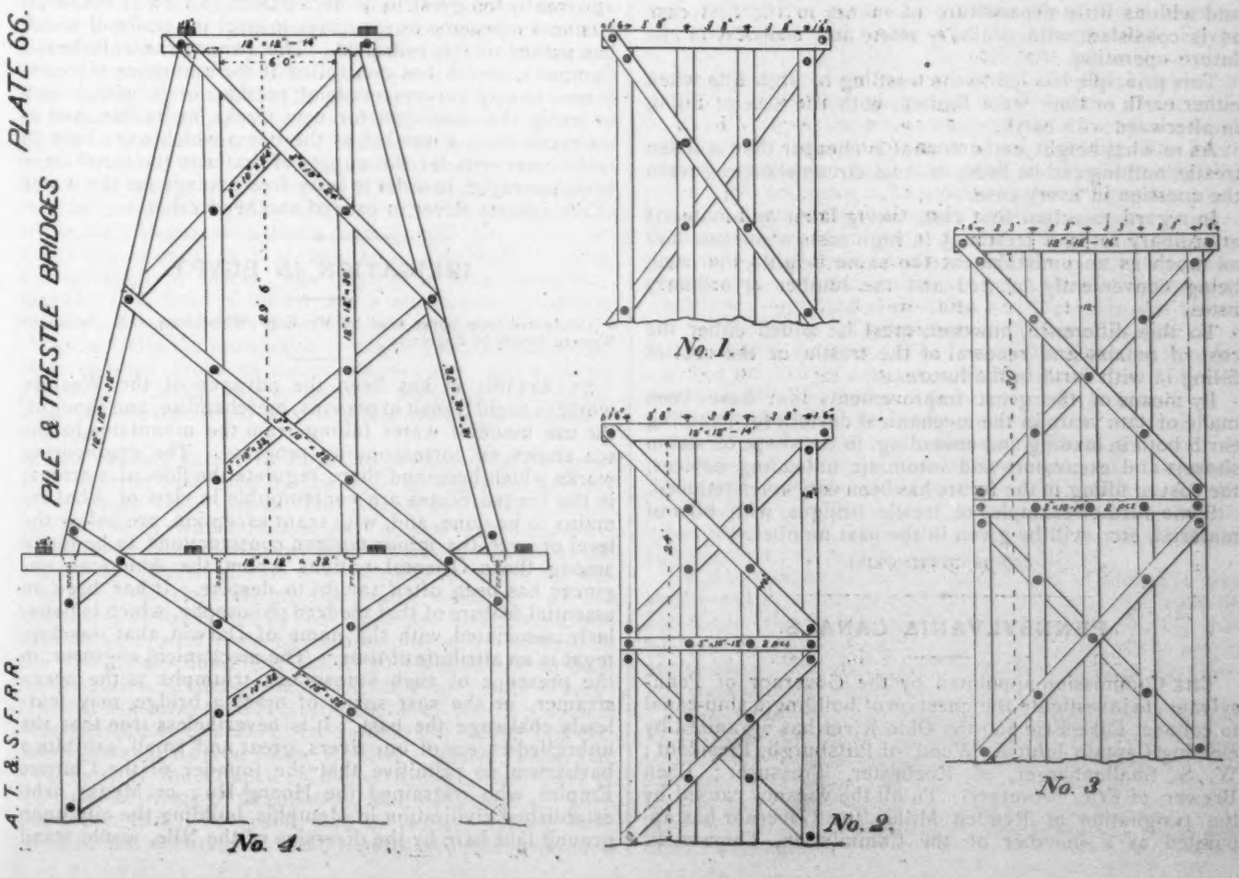


PLATE 66.

A. T. & S. F. R. R.

PILE & TRESTLE BRIDGES



ADD FOR EACH SUCCESSIVE SPAN.

No. Pcs.	Description.	Mark.	Length.
4	Piles, 12" diam.....	*a*	
1	Cap, 12" × 14".....	*b*	14'—0"
4	Track Stringers, 10" × 14".....	*c*	16'—0"
2	Outside Stringers, 10" × 14" ...	*d*	16'—0"
12	6" × 8" Oak Bridge Ties.....	*e*	12'—0"
2	8" × 8" Guard Rail	*f*	16'—0" for every odd span.
2	3" × 10" Cross Bracing.	*h*	
6	10" × 10" Corbels.....	*o*	5'—4"
2	8" × 8" Guard Rails.....	*f*	18'—0" for every even span.
	IRON.		
4	Dowels, 1" diam..... ..	*v*	1'—9"
28	Bolts, ¾" diam., 2" thread.....	*r*	2'—3" under head.
2	2" × 3¾" L's, 6.1 lbs....	*s*	4"
88	Cast Washers..... ..	*t*	
4	Bolts, ¾" diam., 2" thread..	*u*	2'—5¾" under head.
8	Cast Spools.....	*q*	
24	Cast Separators...	*w*	
4	Bolts, ¾" diam., 2" thread	*x*	4'—2" under head.
8	Bolts, ¾" diam., 3½" thread ..	*y*	1'—7¾" under head.
6	Boat Spikes, 5-16" square.....	*z*	5"

The cost of the bents increases with their height (but not in the same ratio), so that the more the bent costs the more expense can be economically incurred to reduce the number of the bents. This can be calculated in any particular case.

The ordinary distance between bents from 10 to 25 ft. in height is 12 to 15 ft., the openings being spanned by chords not braced at all. As the height increases the spans may be made longer and the chords braced. This is carried on until at last we have a regular truss bridge supported at each end upon a bent, or cluster of bents.

Up to a certain height, one row of four posts is sufficient, but beyond that point the number in the row must be increased by one or two, or the bents so arranged in clusters as to permit of proper longitudinal bracing.

One thing that has led to such a general use of wooden trestles in this country is the principle upon which all our railroads are built—viz., to build as rapidly as possible, and with as little expenditure of money in the first case as is consistent with ordinary safety and economy in the future operation.

This principle has led to the trestling of high fills when either earth or time were limited, with the idea of filling in afterward with earth.

As to what height embankment is cheaper than wooden trestle, nothing can be fixed, as local circumstances govern the question in every case.

In regard to actual first cost, taking labor and material at ordinary rates, a trestle 35 ft. high costs about one-half as much as an embankment the same height—the earth being conveniently located and the lumber at ordinary rates.

To this difference, however, must be added either the cost of repairs and renewal of the trestle, or the cost of filling in with earth in the future.

By means of the great improvements that have been made of late years in the mechanical devices for handling earth both in loading and unloading, in the shape of steam shovels and excavators and automatic unloading devices, the cost of filling in the future has been very much reduced.

Some further examples of trestle bridges, with bills of material, etc., will be given in the next number.

(TO BE CONTINUED.)

PENNSYLVANIA CANALS.

THE Commission appointed by the Governor of Pennsylvania to investigate the question of building a ship-canal to connect Lake Erie and the Ohio River has organized by electing Captain John A. Wood, of Pittsburgh, President; W. S. Shallenberger, of Rochester, Treasurer; Eben Brewer, of Erie, Secretary. To fill the vacancy caused by the resignation of Reuben Miller, the Governor has appointed as a member of the Commission, Thomas P. Roberts, of Pittsburgh, Chief Engineer of the Monongahela Navigation Company. The two engineers, who are members of the Commission—John M. Goodwin and Thomas P. Roberts—will direct the surveys which will be made.

The appointment of this Commission was authorized by the Pennsylvania Legislature at its last session, and at the same time a sum of $10,000 was appropriated to pay the necessary expenses. The work to be done is to gather information as to the possibility of building a ship-canal to connect the waters of the Ohio River with Lake Erie, this information to be submitted to the Legislature as a basis for further action on the part of the State. The members of the Commission will begin their work by making a trip over the lines proposed for the canal, and probably more complete surveys will be undertaken.

The only plan submitted, so far, has been one prepared by Mr. G. L. Moody, of Erie, who proposed to make available for the canal three drainage basins, the Chautauqua on the east, the Oil Creek on the south, and the Conneaut or French Creek Basin on the west. From the last-named basin the water for the old Beaver & Erie Canal was drawn. The water from the three basins would be led by feeders to Conneaut Lake, which would be made the reservoir or supply basin for the summit level of the canal. Other engineers are inclined to think that this plan is somewhat too extensive, and that it will not be necessary to draw upon all three drainage basins to supply the water. The whole matter, however, will be carefully considered by the Commission, which includes among its members two able engineers, both of whom are familiar with canal work, and are also well acquainted with the region through which this canal is to pass. The proposed work is one of great importance to the coal and iron interests of Pittsburgh and Western Pennsylvania.

While the State is thus planning a new canal or connection for the West, it has been definitely decided to abandon the old Pennsylvania Canal, which has been in operation for so many years east of the Alleghenies. As has been heretofore noted, the canal from Huntingdon eastward was practically destroyed by the floods of last June, and the expense of repairing, or rather of rebuilding it, was apparently too great to be undertaken, in view of the small business now done by the canal, most of the traffic of which has passed to the railroads. The Pennsylvania Railroad Company, which has controlled it for a number of years, is now having surveys made of portions of it, with a view of using the canal-bed for new tracks for its line, and in the mean time, a number of the dams which were built to make reservoirs for the supply of water to the canal have been destroyed, in order to leave free passage for the water of the Juniata River in case of another freshet.

IRRIGATION IN EGYPT.

[Condensed from paper read by Mr. Cope Whitehouse, C.E., before the Western Society of Engineers.]

STARTLING as has been the advance of the Western world in rapid transit of persons, merchandise, and thought, the use made of water falling from the mountains to the sea shows no corresponding progress. The engineering works which here and there regulate the flow of a stream in the United States are contemptible in view of what remains to be done, and, with scant exception, are below the level of even the minor modern constructions to be found among those Oriental nations whom the American engineer has been often taught to despise. It has been an essential feature of that modern philosophy, which is popularly associated with the name of Darwin, that development is an attribute of time. The mechanical engineer, in the presence of such stupendous triumphs as the ocean steamer, or the vast spans of many a bridge, may fearlessly challenge the past. It is nevertheless true that the unbridled career of our rivers, great and small, exhibits a barbarism so primitive that the founder of the Chinese Empire, who restrained the Hoang-Ho; or Menas, who established civilization in Memphis, building the city upon ground laid bare by the diversion of the Nile, would stand

aghast at the sharp contrast offered by advancement in the use of steam, steel, and electricity, with the utter neglect of that immense force that represented to the rulers of the East so obviously, individual welfare and national empire. Those lords of the Nile would despise us as slaves of the Colorado and the Mississippi, contented to submit with supine tameness to the caprices of our water-courses, as if these rivers were not as amenable to control as the drainage basins of the Abyssinian mountains and the lakes of Central Africa. These questions of irrigation, drainage, and river transportation are hourly assuming greater importance. They have attracted the attention of the American people. They are being carefully studied. The problems will be solved and the difficulties surmounted by that energy and febrile ingenuity which are characteristic of our country. It cannot but prove interesting and instructive to examine irrigation in Egypt, dependent upon that anomalous river which so long ago exercised human thought, and continues to this day to present the same conflict between nature and man.

At the commencement of this century French engineers succeeded, in supreme control, the Pharaohs, the Persians, the Greeks, and the Arabs. Now the ultimate direction is in the hands of about ten British officials trained in India. The native division-engineers, however, are men of great local knowledge and practical as well as technical ability. Ali Pasha Mubarekh, now Minister of Public Instruction, was formerly Minister of Public Works. He is a conspicuous example of success in amassing singularly vast stores of profound and varied knowledge on all subjects connected with the engineering profession.

The current idea of the topography of Egypt is erroneous in the extreme. It is not a sandy plain traversed by a river, whose inundation brings fertility to the farthest parts reached by the life-giving stream. The pyramids are neither in the river, as Shakespeare says, nor in a sea of sand, as Dr. Brugsch describes them. The Nile Valley to the south of Cairo, is sharply distinguished from the Delta. The Nile itself is practically a double stream. The perennial flow is maintained from the great lakes of Equatorial Africa ; the inundation is due to the rain-fall on the Abyssinian mountains. The supply from the end of February, for about three months, is insufficient for the area under actual cultivation. This is little more than one-half the extent cultivated under the Pharaohs or the Ptolemies. The entire area of cultivated land is artificially irrigated. The inundation of Middle Egypt is everywhere controlled by embankments many thousand miles in extent. In Upper Egypt as soon as the water rises out of its deep channel, it is allowed to flow into districts of 50,000 to 80,000 acres. Should it afterward rise higher it is excluded from these shallow pools, where the fertilizing alluvium is deposited, while the villages, with their palm-groves, rise above the water like islands, each secured by its own wall of earth, strengthened by brick. The high Nile thus becomes a menace. Its flood is forced into a comparatively narrow channel, whose bounds it not infrequently bursts.

In the Delta the inundation is wholly excluded whenever such summer crops as cotton, sugar-cane, and rice are growing. Canals supply enough water for the crops. Scarcely one-twentieth of the whole discharge in flood is utilized.

The missing factor in Egyptian prosperity is the great lake Moeris, described by the ancient historians and depicted upon their maps. The Author's discovery of the Raijan Valley, which formed part of this reservoir, offers a means of controlling the flood waters of the Nile, and storing a sufficient portion of its surplus to double the discharge of the river during the annual drought. All the facts have been verified by the Egyptian Government, and reports have been made, based upon the official surveys by Sir C. C. Scott-Moncrieff, Author of the well-known book on Irrigation, Under-Secretary of State for Public Works ; Colonel Western, the Director-General of Works ; Colonel Ross, Inspector-General of Irrigation ; Sir Edgar Vincent, late Financial Adviser to the Khedive ; Nubar Pasha, late President of the Council ; Colonel Ardagh, late Chief of Staff in the Army of Occupation, and many others. Lord Salisbury, Sir J. Ferguson, and Sir Evelyn Baring have attested the accuracy of these reports and have conceded the enormous benefits which would accrue to Egypt from the execution of the proposed canal. The Khedive, with his strong love for the people under his care, has always manifested an appreciative sympathy for my investigations.

The Raijan project is briefly a scheme to put the Nile in communication with a depression, 250 square miles in area, in the desert to the west of the Nile and about 75 miles south of Cairo. Its circuit of 230 miles is bounded by plateaus of horizontal limestone, after rising to a height of 600 ft. Its soil is desert sand overlying rock and yellow clay. About one-tenth of the area is occupied by steep ridges of blown sand, 60 ft. high. It contains no inhabitants. To the south are two springs, warm and sulphurous, with a few date-palms and a little coarse vegetation. Its greatest depth is 153 ft. below the Mediterranean, or about 250 ft. below high Nile in the adjacent valley. It can be readily utilized to relieve the Nile during flood, assist the drainage of Middle and Lower Egypt, and store water for summer use from April to July.

The shortest and most direct channel through the Berek-Abu-Hamed hill is six miles in length. This involves a tunnel or a cutting, with a maximum depth of 160 ft. A longer, but in many respects easier route by the Myana Pass is that which has been most fully considered. It has been surveyed with great care and thoroughness. It requires the handling of about 3,500,000 cubic yards of sand, clay, and soft rock, with an average delivery of the material at 20 ft. above the excavation. The same channel, with a regulator and flood-gates, will be used for both the intake and outflow. The reservoir thus formed would contain about 20,500 million cubic meters, or, say, 5,000,000 million gallons. The average rise of the Nile is about 25 ft. The stratum of water available without pumping would be 250 square miles by 25 ft., less evaporation and loss of head. This would yield an average annual supply of about 5,000 million cubic meters, or, say, 1,250,000 million gallons—equal to a daily delivery of 12,000 million gallons during the season of low Nile. The present minimum supply on which the whole export crop of Egypt depends—its cotton, rice, and sugar cane—is about 20 million cubic meters per diem, or less than one-half the amount which could be profitably employed. The Raijan reservoir would more than double the normal flow of the river at this season. The water is now economized in Upper and Middle Egypt as well as in the Delta. The demand for an increased quantity is immediate and pressing. On the completion of the system of Barrage canals it will require an increase of two-thirds of the present supply to cultivate the land which will be offered for summer cultivation. The total possible increased area of cultivated land has been officially put at 3,000,000 acres. The total volume of Egyptian produce would probably be nearly doubled. Sanitary questions have their economical aspect. The death-rate now rises to 92 per 1,000—yet Alexandria was reputed in the Roman days to be the healthiest city on the Mediterranean, while the neighborhood of Cairo and Memphis was famed for its salubrity. The preservation from disaster is a material consideration. The loss by the excessive inundation has reached $5,000,000, while the insufficient Nile last year was officially declared to have cost $1,500,000.

It may therefore be safely stated that a reservoir and canal of escape can be constructed for $2,500,000. It would not require more than one year to make the canal, and probably three inundations would suffice to fill the basin without prejudice to the interests of the present cultivated area. This represents an addition to the wealth of Egypt of not less than $5,000,000 per annum.

At the conclusion of the paper, Mr. Whitehouse was questioned as to the geology of the Nile and the basin he had discovered, to which he replied at length, stating that no satisfactory explanation had been afforded of the origin of the basin. He also further explained some of the physical conditions of the Nile.

Being asked as to any financial plan having been devised for carrying out the works, he stated that the money could be obtained without difficulty, but the impediments to immediate work were personal ones, in that an American layman had made the discovery and had pushed the enterprise in the face of a large array of engineering talent and official control.

THE PENCOYD STEAM HAMMER.

THE accompanying illustrations show a large hammer which has recently been erected and put in use at the Pencoyd Iron Works of A. & P. Roberts, at Pencoyd, near Philadelphia. The large engraving is taken from a photograph, showing the hammer, with the heating furnaces, cranes, etc. This hammer is used for drawing down and forging steel ingots, and is of unusually large size and solid construction. It was built by the Markische Maschinenbau Anstatt, at Wetter, Westphalen, but the cranes and appliances were made in the Pencoyd shops. It is a single-acting hammer, steam being used only under the piston to lift the hammer-head, and the blow being struck by the force of gravity alone. The hammer-head and moving parts weigh in round numbers 40,000 lbs. The diameter of the cylinder is 1.100 m. (43.3 in.), and the stroke is 2.500 m. (8 ft. 2.4 in.)

The foundation of this hammer was made by excavating the ground to the bed-rock, a depth of about 14 ft. below the floor level of the hammer-shop. Upon this was built a bed of cut stone masonry, upon which the foundation proper of the hammer rests. This consists, in the first place, of two layers of white oak timbers 9 × 12 in. in size, and about 16 ft. long, each layer being bolted together, and the two being laid, as is usually the case with such foundations, in opposite directions. On top of these timbers is placed the cast-iron anvil-block, which weighs in all about 210,000 lbs. This anvil-block is made in four pieces, the bottom or base-plate being 11 ft. 10 in. × 15 ft. 10 in. in size and 21¼ in. thick. The second piece or block is 27½ in. thick, the third 36½, and the fourth 42 in. in thickness, each block being somewhat smaller in surface than the one below. The general form of the anvil-block is that of a truncated pyramid. The different blocks composing it are held together by keys, and after they were in place soft metal (zinc) was poured in, filling all the cracks and interstices between them. On top of the upper cast-iron block is placed the steel anvil-block or die upon which the hammer blow is received. The total height of the foundation from the top of the masonry to the face of the die is 13 ft. 4 in., and the die stands about 2 ft. 6 in. above the floor of the hammer-shop.

The main frame of the hammer consists, as will be seen from the engraving, of two circular columns, built up of wrought-iron plates and angles, supporting a cross-girder, which serves as a platform to sustain the hammer. These wrought-iron columns are 2.850 m. (7 ft. 9½ in.) in height, and vary in diameter from 1.575 m. (5 ft. 2 in.) at the base to 1.318 m. (4 ft. 4 in.) at the top. They rest at the bottom on heavy cast-iron base-plates 6 × 8 ft. in size, placed upon a stone foundation, to which each base-plate is secured by six heavy foundation-bolts passing through the masonry. These base-plates and their foundations are entirely independent of the anvil-block.

The box-girder upon which the hammer rests, is, as before noted, built up of plates and angles. The general form will be readily seen from the engraving. It is 0.942 m. (37.1 in.) in depth, 1.500 m. (59.1 in.) wide, and 7.580 m. (25 ft. 9 in.) long over all. The centers of the pillars are 6.280 m. (27 ft. 7 in.) apart. The girder is open in the center to permit the passage of the hammer-head. Supported on this cross-girder, and secured to it by heavy bolts, are two upright frames of cast-iron; the form of these is shown in the engraving. These cast-iron frames are 2.983 m. (9 ft. 9.5 in.) in height, and carry at the top the entablature, which is also of cast-iron and is a plate 0.616 m. (24.2 in.) in thickness, serving both to connect the frames at the top and also to carry the cylinder. The latter rests upon the entablature; it is 3.020 m. (9 ft. 10.9 in.) in total height.

The general arrangement of the lower frame is such as to give abundant room for handling very large pieces upon the anvil. The clear space between the columns is about 15½ ft. and the hammer-man can work in almost any direction.

The guides are separate from the frame and are bolted to the face of the cast-iron frames. They are in all 12 ft. 6 in long, and extend some distance below the cross-girder of the lower frame, being supported on either side below by cast-iron brackets bolted to the under side of the girder as shown. The ram of the hammer is 2.275 m. (7 ft. 5.5 in.) in length and about 3 ft. 3 in. square in section. It is recessed on either side for the guides, which are single.

The depth of the ram given above does not include the die or steel head, which is keyed upon its lower face, and which is 0.470 m. (18½ in.) in depth. The piston-rod is secured to the hammer-head in the manner shown in the accompanying sketch, fig. 2. In this figure, *G* is the piston-rod; *A A* is a split steel ring tapered to fit the taper on the end of the rod; *B B* is a second steel ring; *C* is a copper plate, and *D D* is a number of thin iron plates. The object of this arrangement is to provide a bed having some elasticity to take up part of the shock. Above the ring, *A A*, two keys, *E E*, pass through the hammer-head and secure the piston-rod in its place.

The method of securing the upper end of the rod to the piston is shown in the same sketch, fig. 1. In this *H H* is the body of the piston; *G* the rod; *I I* a circular split nut,

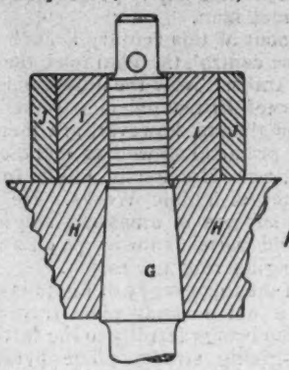


Fig. 1

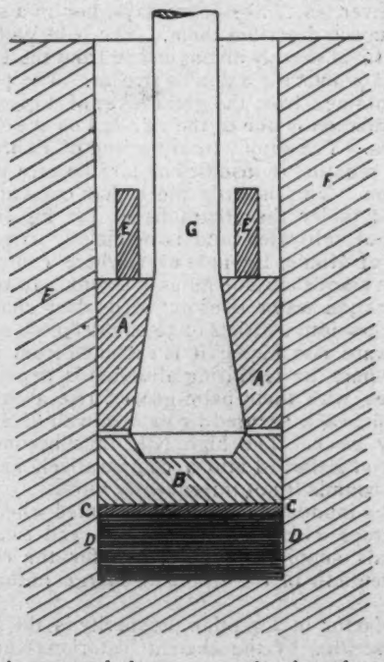


Fig. 2.

which is screwed down upon the thread cut on the upper end of the rod, and *J J* is a steel ring, which is shrunk on over this circular nut after it has been screwed down in place.

The cylinder, as before noted, is 1.100 m. (43.3 in.) in diameter. It is bolted to the entablature by the flange at its lower end, and carries at one side a circular steam-chest through which steam is admitted. This steam-chest contains the valves, which are plain circular valves, of what is often called the Cornish pattern—round valves with flat seats. The steam-pipe is attached directly to the side of the valve-chest as shown. The exhaust passage is cast in the entablature, and the exhaust steam passes out from the bottom of the cylinder. The valves are worked from below by means of a rod and hand lever, placed conveniently for the hammerman.

TWENTY-TON STEAM HAMMER AT THE PENCOYD IRON WORKS.

The piston is of steel, and is simple in construction and sufficiently light to admit of a certain elasticity or spring.

The packing consists of ordinary split rings, four in number, sprung into recesses in the usual way. The upper head of the cylinder is simply a light iron plate, its only purpose being to prevent dust, etc., from falling into the cylinders.

The engraving shows the arrangement of heating furnaces on one side of the hammer; on the other side—partially concealed in the cut by the hammer itself—is a similar set of furnaces, so that there is no delay in providing work for the hammer. There are two cranes—one shown in the engraving and the other, like the second furnace, partially concealed by the hammer itself—which are exactly similar in construction. These cranes have a capacity of 20 tons, an effective lift of 16 ft., and a span of 25 ft.; they can swing a little over a quarter of a circle. The general construction of the frame will readily be understood from the engraving. The lattice-girder, of which the body of the frame is composed, turns upon a heavy wrought-iron pillar or mast, which is 24 in. in diameter and projects 14 ft. 5 in. above the base-plate. These base-plates, upon which the cranes rest, are heavy plates of cast-iron 11 ft. × 11 ft. × 3 ft. thick, resting upon suitable foundations, and the mast or pillar for the cranes, which is tapered on the base, fits into a corresponding recess in the plate. The cranes are worked by three hydraulic cylinders, one being used for swinging the crane around, the second for working the traversing carriage or trolley, which runs on top of the girder, and the third for raising and lowering the chain. In ordinary use these hydraulic cylinders carry 425 lbs. working pressure, but they are built to carry a maximum of 700 lbs., so that the work of the cranes can be increased if necessary.

The whole arrangement of furnace, cranes, and hammer is a very convenient one. The track, which runs the entire length of the works, passes close to the hammer on the side opposite to the furnaces, so that the ingots or other work can be transferred directly from the hammer to a car, upon which they can be carried to the point where it is desired to have them.

This hammer is one of the largest in this country, and has done very satisfactory work since it was put in service a few months ago. That the foundation is an excellent one is shown by the fact that since it was first set up, the anvil-block has sunk only about 4½ in., with the hammer at full work, and the vibration of the ground close by is very slight.

THE DEVELOPMENT OF ARMOR.

By First Lieutenant Joseph M. Califf, Third U. S. Artillery.

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(*Continued from page 516.*)

II.—HOW ARMOR IS CLASSIFIED.

So long as the artillerist confined himself to shot of cast-iron, and wrought-iron held undisputed possession of the field as the metal for armor, the attack and defense in warfare were fairly well matched. That cast-iron for projectiles was decidedly inferior to steel and wrought-iron had been abundantly proven during the earlier experiments with armor, by Whitworth and others, but it was not until the invention of chilled cast-iron shot that the necessity for a new departure in the matter of armor-plate became apparent.

The introduction into the problem of this new factor, of a projectile that had sufficient hardness to pierce and tenacity to hold together when brought in contact with wrought-iron, revolutionized the whole question of armor defense. The armor that was amply able to keep out shot of cast-iron was perforated with perfect ease by the same gun and powder charge firing one of the new projectiles. In other words, the adoption of hard projectiles meant the withdrawal of soft armor.

Before entering into the discussion of the question of the practical use of armor it may be well to give some description of the different varieties, and of the methods employed in their manufacture.

All the different varieties of armor-plate may be classified under one of two heads—soft armor or hard. The behavior of the two kinds when subjected to the blow of a projectile is entirely different. Soft armor opposes the tenacity of its metal to the penetrating effort of a shot. The force of the blow is absorbed locally, and the damage inflicted is confined to the immediate vicinity of the point of impact. There is a crowding up of the particles of metal before the point of the shot, and, if complete perforation takes place, a tearing away at the back of the plate. There is little or no transfer of the shock to the surrounding metal. The attack must depend wholly upon its ability to perforate, to get through the plate in a comparatively uninjured condition, otherwise the value of the shot is lost.

Hard armor, on the other hand, depends for its success upon its ability to withstand penetration—that is, a blow to be efficient against this class of armor must be delivered with energy sufficient to shatter and break up the plate. Theoretically, at least, the possibility of penetration must never be admitted in calculating the resisting power of hard armor-plate. That plates of this description are not infrequently perforated at the experimental butts is, of course, a fact. The aim is, however, to oppose sufficient hardness at the face of the plate, that the energy of the shot may be made to act destructively against itself.

Wrought-iron, in whatever form used, comes under the head of soft armor. As at present employed, hard armor has three subdivisions—*Compound* (a union of wrought-iron and steel), *Steel*, and *Cast-iron*.

III.—SOFT ARMOR.

It took 20 years of experiment to develop from the single thin plate of wrought-iron with which armor experiments began, the solid rolled plate of the same material, of from 6 in. to 8 in. in thickness, which had been reached about the close of our Civil War. Laminated armor, made up of single plates, usually an inch in thickness, had been the natural direction of armor development. It had been thoroughly tested, both with experimental targets and in actual battle, and had been found wanting. It should be said, however, that laminated armor, when employed upon a curved surface, as on the turrets of the *Monitors*, gave much better results than when exposed on a flat surface. Fig. 1 represents the 11-in. laminated armor on the *Monitor* turrets.

The superiority of the solid plate over a laminated one of 1-in. plates, of the same thickness, is very considerable, and is given at various figures, from one-third greater strength to that which varies as the square of the thickness. The latter is probably excessive, for experiments have not shown that a solid 3-in. plate offers equal resistance with a 9-in. built-up one.

With the gradually increasing thickness of armor-plate, corresponding to the growing power of the gun, it was found that there was a practicable limit to the thickness with which solid wrought-iron plates could be produced, and at the same time secure a uniform quality of metal throughout. Beyond 12 in., or, at most, 14 in., it was found difficult to obtain homogeneity of structure. Plates of much greater thickness have been made and experimented with, but the thickness here given is that from which fairly certain results can be predicted. Added to this, was the greatly increased cost of manufacture and the difficulty of accurately joining the plates together.

To escape these difficulties, and still secure proper thickness of metal, further experiments were had, first with plate-upon-plate armor—that is, placing the solid plates in juxtaposition—and afterward with what is known as sandwich armor, or armor where the plates are separated by layers of wood.

In the Russian experiments of 1869 an 11-in. Krupp steel projectile of about 500 lbs. in weight was driven through 15 in. of wrought-iron in two plates, three 1-in. intermediate plates, and 36 in. of wood backing. Up to this time

this was by far the best showing for the gun. Three years later the failure of the 12-in. 25-ton English rifle to perforate or disable the 12-14-in. turret of the *Glatton* showed the advantages of metal when disposed in a circular structure over that exposed on a flat surface.

During 1876-77 a series of experiments were conducted in England against sandwich armor. A 12.5-in. rifle was

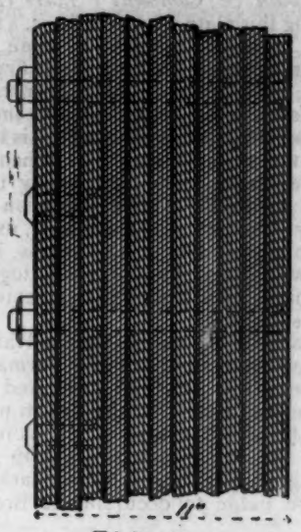


FIG. 1

able to perforate three 6.5-in. solid plates separated by 5-in. layers of teak. The same gun, when fired with an increased charge against the same target, strengthened by the addition of a fourth 6.5-in. plate and another 5-in. layer of teak, failed to get its projectile through the last plate. To test the relative powers of resistance of solid and sandwich armor, a solid 16.5-in. wrought-iron plate, considered equal in strength to the three 6.5-in. plate target above referred to, was attacked by the same gun. A sand-weighted Palliser shell was driven through it without difficulty.

During further experiments with sandwich armor, a target of four 8-in. plates of wrought-iron, with 5-in. layers of teak between the plates, was attacked with the 16-in. 80-ton gun and a 1,700-lb. projectile. The projectile failed to get through, was stopped after penetrating a little over 26 in. of the 32 in. of iron, and the intermediate 15 in. of teak. At a second trial with the same gun, chambered, and with a considerably increased charge of powder against the same target, the projectile penetrated only about 27 in. of metal, but bent back the rear plate of the target some 14 in.

With these experiments the testing of wrought-iron plates may be said to have terminated. The results of the Spezia armor-trials of the year previous, when hard armor had for the first time been put to the test, had shown conclusively that the era of the soft armor-plate had closed.

IV.—HARD ARMOR.

Although experiments with hard armor had been made 20 years before, it was not until the Italian tests in 1876, above referred to, that it had been brought in actual competition with wrought-iron. Up to this time both for use on war vessels, and generally for experimental purposes, this latter metal had held possession of the field. The advent of the 100-ton gun gave such promise of advantage to the attack that new impetus was given to efforts looking to the improvement of armor-plate. In France, and by Whitworth in England, steel had been advocated, and had, at irregular intervals, been seen upon the trial-ground both alone and in conjunction with wrought-iron, but up to that time had never received a thorough test. In 1862 the English Committee on Iron had pronounced against steel or steely iron for armor-plates, while as late as 1874 one of the best English metallurgists, commenting on an experiment that had been made by Armstrong with an oil-tempered steel plate, tells us that iron is superior to steel for purposes of armor.[1]

The Italian Government, which was at this time building the first two of its monster armor-clads—the *Duilio* and the *Dandolo*—before deciding upon the question of their armor, inaugurated a series of experiments at Spezia to test the claims of the armor-plate-makers of Europe. These experiments attracted widespread attention and conclusively demonstrated the superiority of hard over soft armor. Without going into the details of this trial it will be sufficient to say that the targets submitted were intended to represent, as nearly as might be, the thickness of armor that had been decided upon for the new vessels, which was something over 22 in. of metal, including the inner skin, and 29 in. of wood backing. The plates submitted were one English 22-in. solid wrought-iron (Cammel & Company), one French plate of the same material and dimensions (Marrel Frères), and two solid steel 21.65-in. French plates (Schneider & Company). In addition to these both Cammel and Marrel submitted sandwich targets of the usual pattern, aggregating 22 in. of metal, and, besides, each supplied one in which the 22 in. of iron were divided between 8 in. of wrought and 14 in. of chilled cast-iron. Cammel placed these latter plates in juxtaposition, while in the Marrel plate, the cast and wrought-iron were separated by a layer of wood. The test was to be a number of rounds from guns of moderate caliber (10-in. and 11-in. rifles) and one round from the 100-ton gun. All the targets withstood the smaller projectiles fairly well, but that from the heavier gun effected with ease complete perforation in all except the solid steel Schneider plate, which, although shattered and thrown down, had successfully kept out the 2,000-lb. projectile, with a striking energy of something over 30,000 foot-tons. It is not to be wondered at that after these experiments renewed attention should have been given to hard armor.

V.—COMPOUND ARMOR.

Compound armor, as at present understood, is a combination of iron and steel—a hard steel face joined to a wrought-iron back. It is the type of armor invented in and adopted by England.

The idea of joining iron and steel together in one plate was by no means new at the time of the Spezia experiments in 1876. But in the earlier attempts to join the metals the steel plate was usually welded to its companion, sometimes to the face, sometimes to the back, and in other cases placed between two plates of iron; or the plate was made up of alternate layers of iron and steel welded together. Cammel & Company had entered the lists as early as 1867 as manufacturers of armor-plates made up of a combination of iron and steel, but it was not until 10 years later that they produced their first compound plate manufactured upon the lines now generally adopted.

There are two firms engaged in the manufacture of compound armor-plates in England, by whose names the two varieties of armor are generally known—Cammel & Company and Brown & Company, both of Sheffield. These are also frequently referred to by the names of the patentees—Wilson and Ellis. Armor under the Wilson patent is also manufactured in France, in Germany, and in Russia. The Cammel plate is now manufactured under two patents known as No. 1 and No. 2.

Cammel & Company's Plate, No. 1 (Wilson's patent). In the manufacture of this plate, shown in fig. 2, the foundation-plate or backing is built up of many thin plates rolled down to the thickness of the plate required. It is then raised to a welding heat, placed in an iron mold or chamber, which revolves on trunnions. The mold is then turned to a vertical position and liquid steel (Siemens-Martin, or open-hearth) is poured from a ladle and trough between one side of the wrought-iron and the side of the mold, precaution being taken to prevent its flowing elsewhere. As soon as sufficiently cold it is taken from the mold, reheated, and rolled down to its final thickness, in one heat if possible. The steel being of higher temperature than the iron carbonizes the iron to a depth of from $\frac{1}{4}$ in. to $\frac{1}{2}$ in., forming a zone of mild or semi-steel and a strong welding joint. The steel face contains about 0.7 per cent. of carbon.

In the earlier process the wrought-iron plate was placed horizontally and the liquid steel poured over the face of the

plate. This was abandoned because the scum remained on the face of the plate and impaired its quality.

Under the Cammel, No. 2, or Wilson's improved process, to produce a 20-in. finished plate, a plate of about 15 in.

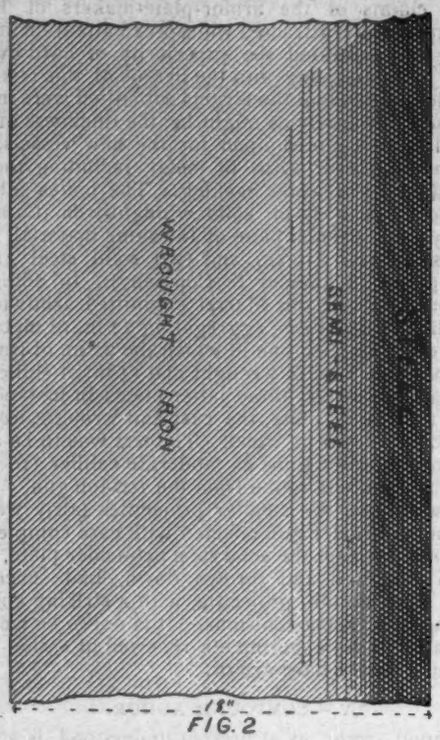


FIG. 2

in thickness is built up of a number of thinner plates as before. After this plate is forged, and before cooling, it is placed in an iron mold about 28 in. in depth, and upon its face is run a layer of very mild steel—Bessemer or

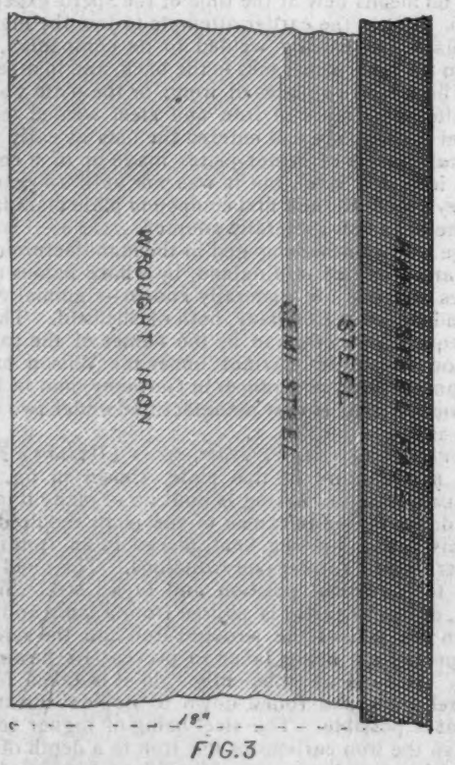


FIG. 3

Siemens-Martin—about 13 in. in depth. When cool the plate is taken from the mold, reheated, and then rolled or hammered until the thickness is reduced to about 18 in. This forms the back of the compound plate. After being replaced in the mold a layer of hard steel, about 8 in. in thickness, is run upon the originally exposed face of the wrought-iron plate, giving a thickness of about 26 in. It is then removed from the mold and after being reheated is reduced by rolling or hammering to the required thickness of 20 in. The hard steel face of these plates contains from 1.25 to 1.50 per cent. of carbon.

Sir John Brown & Company's Plate (*Ellis patent*). In manufacturing this plate, shown in fig. 3, a soft, wrought-iron backing is prepared in much the same way as in the ordinary Wilson process. A hard, steel-finished plate is also prepared. The steel plate is laid over the foundation-plate, their surfaces being kept about two inches apart by wedges and small steel studs. The whole is then heated in a furnace with the plates horizontal. When hot it is removed and lifted by a crane and swung into a vertical mold in a pit, a hydraulic ram in the mean time holding the plates firmly. Melted steel (Bessemer, usually) is then distributed from a trough, in small streams, into the space between the two plates, joining them together. After being taken from the mold the plate is reheated and passed through the finishing rolls.

In the fabrication of both the Cammel and the Brown plates the greatest difficulty lies in the formation of a perfect weld between the iron and steel, and in the latter between the steel and steel. In the Brown plate there are two surfaces to be joined instead of one, as in the Cammel armor. Under fire the metals are apt to separate, the steel face flaking off from the soft iron backing. This is said to be more liable to occur in the Brown than the Cammel plate.

The advantage claimed for the Brown plate is that a perfectly finished face of known hardness is secured, which, of course, is not the case with its rival. It has the disadvantage before stated, that the union between the face and back is less perfect.

These two rival systems of compound armor about equally divide the favor of English artillerists and metallurgists. Under actual firing tests there seems little to choose between them.

The plates, as generally made, are about 8 ft. by 12 ft., and weigh, for the thicker ones, from 45 to 50 tons each. About one-third of the thickness of a compound plate is of steel, and two-thirds of wrought-iron.

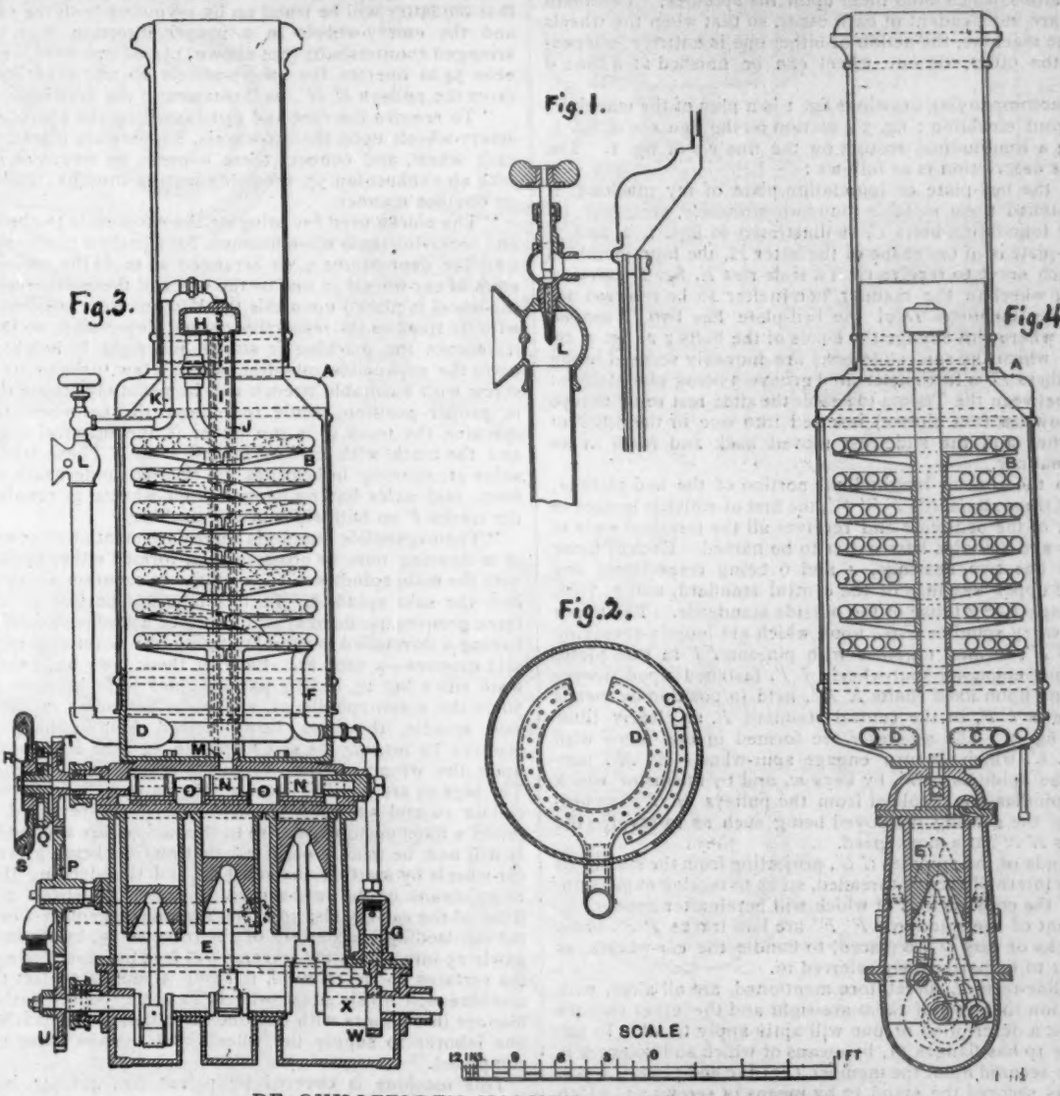
(TO BE CONTINUED.)

A French Naphtha Launch Engine.

(From *Industries*.)

AMONG the petroleum vapor launch engines at the Paris Exposition is one exhibited by La Société Anonyme des Anciens Etablissements Cail, who obtained, about the end of last year, the exclusive right to manufacture in France and its colonies and protected dependencies M. de Quillfeldt's petroleum vapor engine for river and sea-going craft. As there are some novel points in the Quillfeldt engine, we propose to describe it in detail. Fig. 3 is a longitudinal section through the center line of the generator and motor, and fig. 4 is a cross section through the center of the middle cylinder and generator. From these illustrations it will be seen that the motor consists of a three-cylinder engine, the cylinders being single-acting, and about 3 in. in diameter by 4-in. stroke. Immediately above the engine is the vaporizing apparatus, making a very compact arrangement. The burners *C D* (fig. 2) for raising the temperature of the petroleum are placed below the spiral tubing of copper in which the oil circulates, so that a considerable amount of heat is radiated to the cylinders, thereby maintaining the temperature of the spirit vapor and increasing the efficiency of the motor. The principal feature of the Quillfeldt motor is that instead of having two distinct qualities of oil in the storage tanks —viz., gasoline and petroleum, only the latter is required, which, it is claimed, obviates the possibility of disastrous explosions, and has also the advantage that there can be no difficulty in obtaining the oil in all localities, since ordinary petroleum is to be bought everywhere. The generator *B*—a copper coil surrounded with a cylindrical casing *A*—is supplied in the first instance with petroleum by means of a small hand-pump, the operator also alternately working a small air-pump, thereby introducing into the auxiliary burner *C*, placed at one side of the principal burner *D*, a mixture of air and vapor, which is ignited by a torch. After ignition the operator continues to work the

hand-pumps for from three to four minutes, when the petroleum in the coil *B* becoming heated, is divided into light and heavy vapors, both of which rise through the pipe *J* into the box *H*, where the lighter vapor passes out of the top of the box and through the pipe *K* to the injector *L*, of which we give an enlarged view in fig. 1. From this illustration it will be seen that a valve is fitted into the funnel-shaped opening of the injector for the automatic admission of the air required to be mixed with the light petroleum vapor to produce combustion in the burner *D*. The draught of the funnel, aided by small openings in the outer casing *A* underneath the burners, proves sufficient for the efficient consumption of the combined petroleum vapor and air, the products of combustion passing directly into the chimney. Meanwhile the heavier vapor escapes from the box *H* by the pipe *I*, descending which it enters the valve chest common to the three cylinders by the opening *M*, and then acts through the revolving slide valves *N* upon the pistons. The cranks are set at an angle of 120°, the shaft being carried upon bearings formed in the bed-plate. The shafting actuating the slide-valve motion is similarly supported at *O O*, and the reciprocal position of the main and slide-valve shaft is such that the slide valves are full open at the commencement of the downward stroke of each piston, so giving a most effective distribution of vapor. The slide-valve shaft is driven by gearing off the main shaft, the spur-wheel *U* actuating the intermediate toothed-wheel *P*, which transmits the motion to the geared-wheel *T* on the valve-spindle. This gearing arrangement does not merely transmit motion to the slide-valves; it is also utilized for reversing, starting, and stopping the mechanism. To reverse the motion from go ahead to go astern, the wheel *S* is turned in a direction contrary to its motion. After the engine is once in motion there is no longer any necessity to pump either air or petroleum by hand. As already explained, the air supply is automatic, while a feed-pump, *G*, serves to draw petroleum from the reservoir at the fore end of the boat, and force it into the vapor-generating coil by the pipe *F*. The rod of an eccentric, *W*, placed on the main shaft near *X*, gives the requisite motion to the plunger of the pump *G*. A pressure-gauge connected to the slide-valve casing is fitted on the port side, and a safety-valve on the starboard side; but in practice the latter should rarely be in operation, because if the pressure is increasing too rapidly, a slight adjustment of the injector will soon diminish the supply of vapor to the burner, and check the increase of pressure. An internal arrangement is also fitted in connection with the pipe *K* to prevent an excessive amount of vapor passing to the burner. This is, however, only necessary if a kind of oil is used sensibly different from that for which the engine has been designed. In practice it is found that the proportion of light vapor given off from ordinary petroleum is just sufficient for the heat supply to the generator and no more; but should there occur a variation in the specific gravity of the petroleum, it might upset the delicate adjustment of the heavy and light vapors, and hence means for checking readily the passage of light vapor to the burner have been provided.



DE QUILLFELDT'S NAPHTHA LAUNCH ENGINE.

After the petroleum vapor has been utilized as the working agent, it exhausts from the cylinders into a condenser formed of tubes laid alongside the keel of the boat, from which it returns into the storage tank. When the engine is once set in motion, its operations are entirely automatic, and hence it does not require a skilled attendant.

The consumption of oil is stated at about 1 gal. per hour for a 2-H.-P. motor, which, at a specific gravity of 0.80, is equal to 4 lbs. of fuel per indicated H.-P. per hour. Similarly, the mean result for the 4-H.-P. engine is a consumption of 2.90 lbs. petroleum per indicated H.-P. per hour. These figures, however, must be taken only as an approximation.

Apart from the question of economy, however, there is no question that these vapor launches, with a compactly arranged motor like this one, have advantages over the ordinary steam launch, in giving more room for passengers and in the absence of noise, smoke, waste, and exhaust steam. With ordinary care there seems to be no risk of explosion.

Griffin's Car-Wheel Grinding Machine.

THE accompanying illustrations show a machine for grinding and truing up the treads and flanges of car-wheels. As will be seen, it is so arranged as to carry two wheels at once, each wheel being acted upon by two emery-wheels or grinders. This machine has a further advantage, that it is not necessary to mount the wheels upon the axles, as they are carried by expansion mandrels which hold them upon the spindles. The main spindles are independent of each other, so that when the wheels are on the machine, the action of either one is entirely independent of the other, or one wheel can be finished at a time if desired.

In the accompanying drawings fig. 1 is a plan of the machine; fig. 2 a front elevation; fig. 3 a section on the line *x x* of fig. 1, and fig. 4 a longitudinal section on the line *y y* of fig. 1. The inventor's description is as follows:

"*A* is the bed-plate or foundation-plate of my machine, it being fastened upon suitable foundation-timbers, etc., *B B*, by means of foundation-bolts *C*, as illustrated in figs. 1, 2, and 3. This bed-plate is of the shape of the letter H, the four members *D* of which serve to receive each a slide-rest *E*, fig. 1, carrying an emery-wheel in the manner hereinafter to be referred to. Each of the members *D* of the bed-plate has two T-shaped slots 1 1, wherewith engage the heads of the bolts 2 2, fig. 2, by means of which the said slide-rests are movably secured upon said members *D*, a further serrated groove 3 being placed about midway between the T-slots to enable the slide-rest to be moved with a crow-bar (not shown) inserted into one or the other of said notches and the slide-rest moved back and forth in an obvious manner.

"Upon the central longitudinal portion of the bed-plate *A*, are placed three standards *F F' F''*, the first of which is located in the center of the bed-plate and receives all the terminal ends of the shafts and spindles hereinafter to be named. Each of these standards has two bearings, 4 and 6 being respectively the lower and upper bearings of the central standard, and 5, 7, 5', and 7', respectively those of the outside standards. The upper bearings carry spindles *G G'*, upon which are loosely-revolving pulleys *H H'*, formed together with pinions *I I'* in one piece, said pinions engaging spur-wheels *J J'*, fastened upon sleeves *j*, revolving upon fixed shafts *K K'*, held in position by means of set-screws *k k'*, in the central standard *F*, as clearly illustrated in fig. 4. The sleeves *j* are formed in one piece with pinions *L L'*, which in turn engage spur-wheels *M M'*, fastened to the spindles *G G'*, by keys *m*, and by means of which the said spindles are revolved from the pulleys *H H'*, the proportions of the gearing employed being such as to revolve the car-wheels *N N'* at a slow speed.

"The ends of the spindles *G G'*, projecting from the standards *F F'*, are internally screw-threaded, so as to receive expansion-mandrels, the construction of which will hereinafter appear.

"In front of the standards *F' F''* are laid tracks *P P'*, upon which trucks or cars *Q* are placed, to handle the car-wheels, as hereinafter to be particularly referred to.

"The slide-rests *E*, heretofore mentioned, are all alike, with the exception that two of them are right and the other two are left, so that a description of one will aptly apply to all. In fig. 3, the base 10 has flanges 11, by means of which and bolts 2 it is removably secured upon the member *D* of the bed-plate. Upon this base is secured the stand 12 by means of screws 13, which stand has ways 14 for a traverse 15 on its upper side, having the slide 16 moving at right angles to the traverse 15, and provided on its upper surface with two bearings 17, carrying between them a pulley 18, which pulley is secured to a mandrel 19, the forward end of which has an emery-wheel 20, all as clearly illustrated in figs. 1 and 3. The traverse 15 is moved by a screw 21, having on its end a hand-wheel 22 and a ratchet-wheel 23, there being further secured upon said screw a lever 24, figs. 1 and 3, which actuates said ratchet-wheel (and with it the screw 21) by the pawl 25 and spring 26. This spring 26 is of substantially U-shape, one member being fastened to said lever 24, and its free end pressing upon the tail of the dog or pawl 25 in a manner easily comprehended.

"To the bed-plate *A* are fastened four supports 27 (fig. 1 showing but one, and figs. 2 and 3 but two thereof, they having been omitted from said fig. 1 so as not to crowd the same with details which would have a tendency to obscure the drawings), to the upper end of which are pivoted levers 28, having their fulcrum about midway of their length. One of the ends of these levers reaches a short distance beyond the periphery of the spur-wheels *M* or *M'*, so as to come in contact with pins 29, which pins depress the ends of these levers on one side of the machine and lift the opposite set of levers on the opposite side, the motion up or down depending upon the direction of revolution of the machine. To the end of the lever 28 is pivoted a rod 30, which connects said lever with the lever 24 by means of a bolt 31, there being a series of bolt-holes 32 in these various levers, so as to lengthen or shorten their throw at pleasure, and thereby the feed of the slide 16, together with the emery-wheel 20, in a manner readily comprehended.

"The stands 12 are movably fixed to the bases 10, so as to enable them to revolve around a fixed center, and thereby to be set at an angle to the center line of the axes of the main spindles *G G'*, the angle being that of the tread of the car-wheels *N*, so that the latter will be trued up by revolving both the car-wheels and the emery-wheels in a proper direction from suitably-arranged countershafts (not shown) placed overhead, and having belts 34 to operate the emery-wheels 20 and other belts 33 to drive the pulleys *H H'*, as illustrated in the drawings.

"To remove the dust and grit caused by the operation of the emery-wheels upon the car-wheels, hoppers are placed 35 under each wheel, and connect these hoppers by means of ducts 36, with an exhaust-fan 37, receiving motion through the belt 38 in an obvious manner.

"The trucks used for bringing the car-wheels to the machine and removing them when finished, have in their platform curved, step-like depressions 9, so arranged as to fit the various diameters of car-wheels in one or the other of these depressions. A car-wheel is placed upon this truck in an erect position, resting with its tread in its respective curved depression, so that when it reaches the machine it stands just right in height to slide upon the expansible mandrel, where a few turns of its spindle-screw with a suitable wrench will immediately secure the wheel in proper position, while to remove the car-wheel from the machine the truck *Q* is run under it, the mandrel contracted, and the truck with its load moved away. These trucks have axles 41, running in bearings 42, secured underneath the platform, said axles having flanged truck-wheels 43 running upon the tracks *P* on both sides of the machine.

"The expansible mandrels heretofore mentioned consist each of a tapering nose or projection 44, formed either in one piece with the main spindles *G G'*, or they are separate pieces screwed into the said spindles. In this tapering portion 44 there are three grooves 45, dovetailed to receive a wedge-shaped jaw 46, having a dovetailed portion 47 fitting the dovetailed portion of said grooves—a nice fit. Each of these jaws has near its forward end a lug 49, having parallel sides to fit between a collar 50 on the screw-spindle 51, and a further collar 52, secured to said spindle, the jaws being moved longitudinally in said grooves by turning the screw-spindle 53 with a wrench placed upon the wrench-section 51 on the end of said screw-spindle. The lugs 49 are parallel because they move radially between the collars 50 and 52 when the screw-spindle is revolved, and so retain a fixed position relative to the said collars and the spindle. It will now be readily observed that motion being given to the car-wheels by starting the machine and then feeding the slides 16 by means of the feed-screws 39 and hand-wheels 40 to the tread of the car-wheels, and then starting the emery-wheels and the self-feeding mechanism of the traverse 15, by throwing the pawls 25 into action the traverse will feed the emery-wheels over the surfaces to be reduced, it being a matter of fact that this machine will finish 40 car-wheels in a thoroughly satisfactory manner in 10 hours with but one attendant to the machine and one laborer to supply the wheels and remove those that are completed."

This machine is covered by patent No. 411,344, issued to P. H. Griffin, of Buffalo, N. Y., under date of September 17 last.

Manufactures.

Locomotives.

THE Schenectady Locomotive Works, Schenectady, N. Y., are building 25 new engines for the Lake Shore & Michigan Southern Railway; three of these are heavy passenger engines, 15 mogul freight, and seven switch engines.

RECENT orders at the Baldwin Locomotive Works include 14 freight engines for the Lehigh Valley Railroad, and 11 mogul freight engines for the Fort Worth & Denver City Railroad. The works recently completed several passenger engines for the Baltimore & Ohio Railroad, which are built to burn coke and which will be used on the line between Philadelphia and Washington.

THE Schenectady Locomotive Works are preparing to begin the construction of a mogul compound locomotive. The engine will be of about the same power as ordinary moguls of the same weight, and will have two cylinders arranged in the same way, except that one will be large enough to perform the duties of a low-pressure cylinder. Mr. A. J. Pitkin, Superintendent of the Schenectady Locomotive Works, has designed this engine, and some inventions that he has got out for regulating the admission of steam to the cylinders have been covered by letters patent. Steam will be admitted to the low-pressure cylinder direct in starting, but reduced in pressure so that the power transmitted on that side will never be greater than that trans-

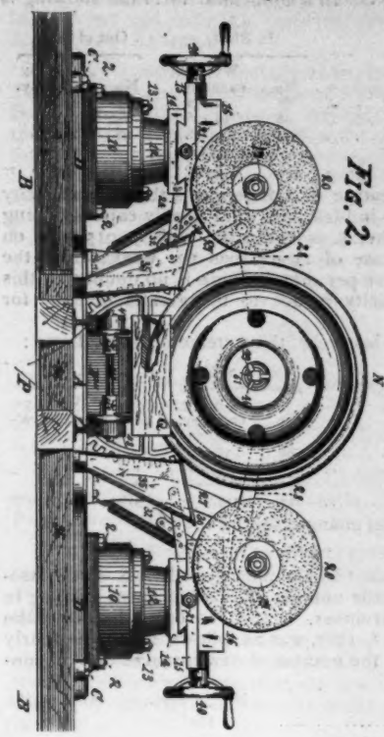


FIG. 2.

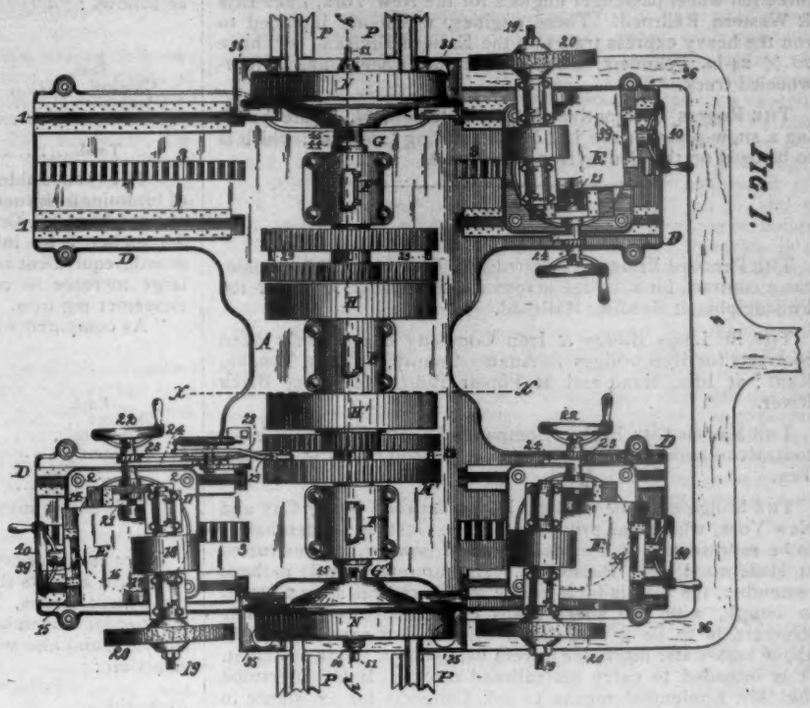


FIG. 1.

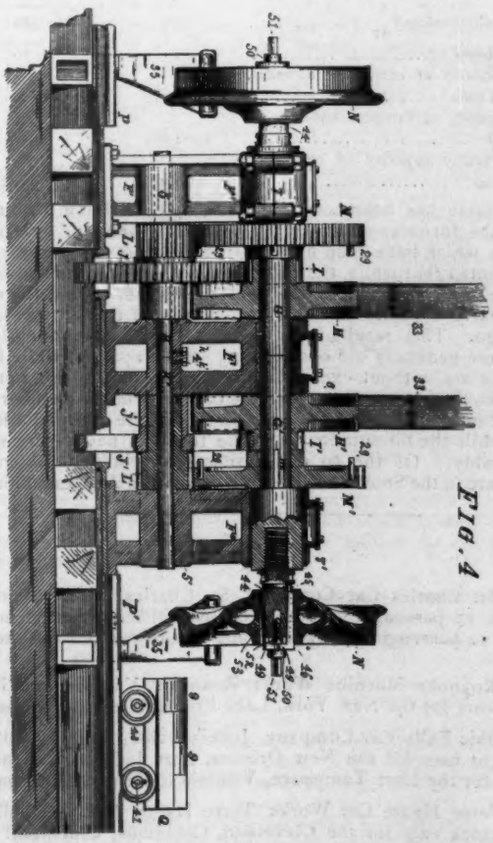


FIG. 4.

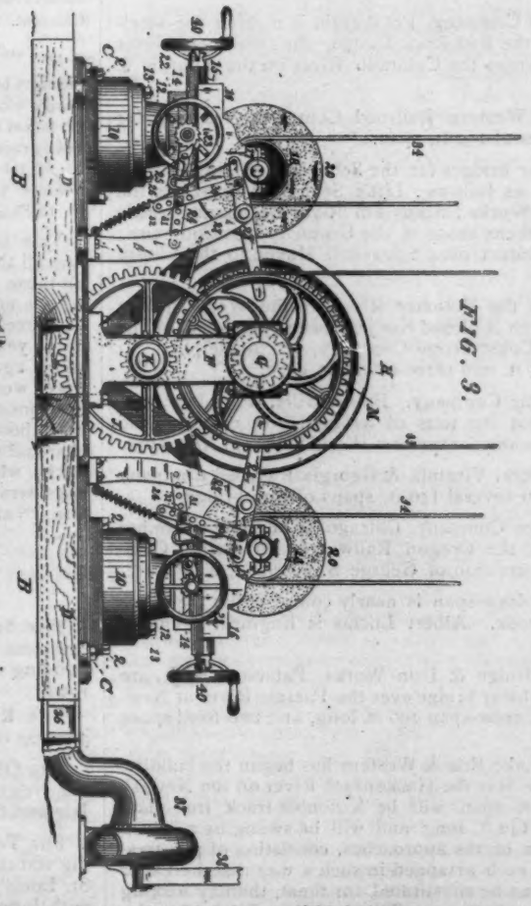


FIG. 3.

MACHINE FOR GRINDING CAR-WHEELS.

mitted by the small high-pressure cylinder. The mechanism of the compound locomotive will not be any more complex than that of a simple engine, and it will be as easily operated. The intention is to subject this engine to searching tests working

against a common engine of the same capacity. The builders are determined to know exactly what there is in the compound locomotive.—*National Car-Builder.*

THE Baldwin Locomotive Works, Philadelphia, are building three ten-wheel passenger engines for the New York, Lake Erie & Western Railroad. These engines, which are intended to run the heavy express trains on the Eastern Division, will have 20 × 24-in. cylinders, six 68-in. driving-wheels, and a four-wheeled truck.

THE Rogers Locomotive Works, Paterson, N. J., are building a snow-plow for the Jull Manufacturing Company, which is to be used on the Pennsylvania Railroad.

Bridges.

THE Pencoyd Bridge & Construction Company, Philadelphia, has a contract for a bridge across the Schuylkill River for the Philadelphia & Reading Railroad.

THE St. Louis Bridge & Iron Company has recently taken contracts for iron bridges in Adams County, Ill.; at Topeka, Kan.; at Iola, Kan., and at Poplar Bluff, Mo., over Black River.

THE Kansas City Bridge Company, Kansas City, Mo., has a contract to build an iron bridge over Chacon Creek at Laredo, Tex.

THE bridge over the Hudson River, between Jersey City and New York, which was proposed by Mr. Gustave Lindenthal, is to be represented by a model which is now being constructed at Hazelwood, near Pittsburgh. As our readers will perhaps remember, the plan is for a bridge with a central span 2,850 ft. in length, with two shore spans each about 2,500 ft. The structure is to be a suspension bridge, with roadway 140 ft. above high-water mark, the towers being about 500 ft. in height. It is intended to carry six railroad tracks. It is understood that Mr. Lindenthal means to ask Congress for assistance in building the bridge.

THE Carbon Iron Company, Pittsburgh, is making the steel-plates and bars for the Red Rock Bridge—the 660 ft. cantilever bridge which is to cross the Colorado River on the Atlantic & Pacific Railroad.

THE Norfolk & Western Railroad Company is asking for bids for four bridges of 150 ft. span.

THE contracts for bridges for the Schuylkill & Lehigh Railroad have been let as follows: Little Schuylkill Bridge to the Edge Moor Bridge Works; Schuylkill River Bridge and trestle approach to the Athens shops of the Union Bridge Company; 1,500 ft. of iron viaduct near Schuylkill Haven to the Elmira Bridge Company.

THE bridge over the Potomac River for the West Virginia Central & Pittsburgh Railroad has just been completed by the Pencoyd Bridge & Construction Company, of Philadelphia. It has one span of 125 ft. and three of 120 ft. each.

THE Phœnix Iron Company, Phœnixville, Pa., has completed its contract for 800 tons of wrought-iron columns and 1,000 tons of steel beams for the new *World* building, New York.

THE East Tennessee, Virginia & Georgia Railroad Company is asking for bids for several 150-ft. spans of iron bridge.

THE Lassig Bridge Company, Chicago, is building a number of iron bridges for the Oregon Railway & Navigation Company, under the supervision of George S. Morison, Engineer.

THE Wilmington draw-span is nearly completed at the shops of Dana & Westbrook. Albert Lucius is Engineer in charge of the work.

THE Riverside Bridge & Iron Works, Paterson, N. J., are building an iron highway bridge over the Passaic River at Newark, N. J. It has a draw-span 196 ft. long, and two fixed spans each 66 ft. long.

THE New York, Lake Erie & Western has begun the building of a new drawbridge over the Hackensack River on the Newark Branch. The draw span will be a double-track iron-plate girder deck bridge 142 ft. long, and will be swung by a steam engine. The length of the approaches, consisting of pile trestles, will be 260 ft., each arranged in such a way that hereafter deck-plate girders can be substituted for them, thereby making the whole structure permanent. The contractor for the foundation and woodwork is Mr. D. S. Cofrode. The ironwork is being done by the Riverside Bridge & Iron Works of Paterson, N. J.

Blast Furnaces of the United States.

THE *American Manufacturer* says of the condition of the furnaces on October 1: "In a condensed form the showing is as follows:

	In Blast.		Out of Blast.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	66	12,672	97	12,071
Anthracite	98	36,496	91	23,818
Bituminous	149	104,378	98	44,086
Total	313	153,546	286	79,975

"The remarkable feature of this report is the large capacity of bituminous furnaces in blast, the total weekly capacity being 104,378 tons on October 1, as compared with 92,915 tons on September 1, an increase of 11,463 tons per week during the month, equivalent to 12½ per cent. There is no doubt that this large increase in capacity is due to the greater demand for Bessemer pig iron.

"As compared with last year, the statement is as follows:

	Oct. 1, 1889.		Oct. 1, 1888.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	66	12,672	73	12,983
Anthracite	98	36,496	99	29,586
Bituminous	149	104,378	138	87,141
Total	313	153,546	310	129,710

"This shows material changes during the year."

FROM statistics collected by the American Iron & Steel Association, it appears that the number of blast furnaces existing in the United States, November, 1, 1889, as compared with the number on November 1, 1887, was as follows, with their yearly capacity, and also with the number of new furnaces now in construction:

Furnaces.	Nov. 1, 1889.	Nov. 1, 1887.
Anthracite	190	200
Bituminous and Coke	239	214
Charcoal	146	168
Total completed	575	582
Furnaces building	29	30
Yearly capacity of completed furnaces, in net tons	13,168,233	10,990,993
Yearly capacity of furnaces building, in net tons	1,204,000	1,122,000
Average yearly capacity of completed furnaces	22,901	18,885

This table has been carefully made up by striking from the line all the furnaces which have been abandoned, and entering all those which have been built during the past two years. It will be noted that while the actual number of furnaces shows a decrease, the total capacity is largely increased, so that the average yearly capacity is considerably greater than it was two years ago. This results from the fact that the abandoned furnaces were generally old ones of very small capacity, while the new ones are without exception large. It will also be noted that there has been a considerable decrease in the number of charcoal furnaces, and a small one in that of the anthracite furnaces, while the bituminous and coke furnaces have increased considerably. Of the 29 new furnaces now under construction, 18 are in the Southern States; 8 of them in Alabama alone.

Cars.

THE St. Charles Car Company, St. Charles, Mo., recently delivered 17 passenger cars to the Union Pacific, and is now building 12 passenger, 4 baggage, and 4 mail cars for the same road.

THE Roanoke Machine Works, Roanoke, Va., are building 300 box cars for the New York, Lake Erie & Western Railroad.

THE Ohio Falls Car Company, Jeffersonville, Ind., is building freight cars for the New Orleans, Fort Jackson & Grand Isle and for the East Tennessee, Virginia & Georgia Railroad.

THE Terre Haute Car Works, Terre Haute, Ind., are building 100 stock cars for the Cleveland, Columbus, Cincinnati & St. Louis Railroad. These cars are fitted with air-brakes and with Janney coupler.

THE United States Rolling Stock Company is building in its shops at Hegewisch, Ill., 100 gondola cars for the Pittsburgh, Cincinnati & St. Louis Railroad.

It is stated that negotiations have been completed for the sale of the Harrisburg (Pa.) Car Works to an English syndicate at a price satisfactory to the stockholders.

The Missouri Car & Foundry Company, St. Louis, is building 200 box and 200 stock cars for the Pittsburgh, Cincinnati & St. Louis Railroad.

Recent contracts reported as let for cars, are as follows: For the Chicago & Northwestern Railroad, 1,000 box-cars to the Peninsular Car Company, Detroit, Mich.; 500 coal cars to the Terre Haute Car Works. For the Lake Shore & Michigan Southern, 700 box-cars to the Peninsular Car Company, Detroit, Mich.; 400 box-cars to the Barney & Smith Manufacturing Company, Dayton, O.; 200 box-cars to the Indianapolis Car Company and 100 to the Buffalo Car Works. For the Pittsburgh & Western Railroad, 900 coal cars to the Indianapolis Car Works, and 600 coal cars to Pennock Brothers, Minerva, O.

Signals.

The Union Switch & Signal Company has taken a contract to equip the Central Railroad of New Jersey from Jersey City to Bergen Point with its pneumatic block system. The work is now in progress.

The Johnson Railroad Signal Company has the contract for an interlocking system at Millstone Junction, N. J., on the Pennsylvania Railroad.

The Gould-Tisdale Revolving Semaphore Company has recently sold two of its signals to the Delaware, Lackawanna & Western, and four to the Elmira, Cortland & Northern Railroad.

The Johnston Electric Train Signal Company, Boston, has equipped several trains on the Boston, Revere Beach & Lynn Railroad with its electric train signals. This is the first practical test of this system, and it is so far giving very good satisfaction.

A special test was made recently of the Rowell safety stop for trains, on the Old Colony Railroad near Boston. The experiments resulted very successfully. This device, which was invented by Mr. B. C. Rowell, of Boston, consists of two parts; a bar carrying a roller which is attached to the engine just ahead of the forward truck-wheel and connects with the air-brakes; the other part consists of a flat iron bar beside the rail, so arranged that when thrown into position it will strike the roller on the engine, and the air-brakes on the train will be instantly set. It is especially designed for crossings and switches, but can be applied at any desired point. Where the locomotives are supplied with this device, a portable wooden bar with iron clamps to attach it to the rail can be carried on trains and put in position at any desired point by the trainmen, when it is necessary to signal or to stop a following train.

Marine Engineering.

The new steamer *Argus* was launched recently by the Jonson Foundry & Machine Company, New York. The boat is built for the United States Government and is intended for the use of the Supervisor of the Port of New York. The *Argus* is of steel, 85 ft. long, 15 ft. 9 in. beam, and 9 ft. in depth. The engine is a Jonson compound engine, with cylinders 12 in. and 21 in. diameter and 15 in. stroke, and steam is furnished by a Cowles water-tube boiler. This, we believe, is the first steel vessel ever built in New York.

The Cleveland Ship Building Company recently completed the new steamer *Pontiac*, which is intended to carry ore from the Lake Superior region and is owned by the Cleveland Iron Mining Company. She has a capacity of 3,200 tons of iron ore, and is 300 ft. long on the keel, 320 ft. over all, 40 ft. beam, and 25 ft. molded depth. She has a water-bottom 3½ ft. deep divided into seven compartments, and can carry some 800 tons of water ballast. The engine is of the triple-expansion type, with cylinders 24 in., 38 in., and 61 in. diameter and 42 in. stroke. Steam is supplied by three steel boilers of the Scotch type, 11 ft. 6 in. diameter by 14 ft. long, and built to run at 160 lbs. working pressure. The propeller is 13 ft. 6 in. diameter and 17 ft. pitch. The boat is equipped with steam steering engines, steam windlass, and steam capstans, and is lighted throughout by electricity.

The Detroit Dry Dock Company has taken a contract to build a steel steamer for the Inter-Ocean Transportation Company. The new craft will have an average length of 330 ft., with 42-ft. beam and 24-ft. depth of hold. An important feature in her construction will be the introduction of a water-bottom capable of carrying 1,000 tons of water ballast, which will enable her to face the most boisterous weather, while otherwise in light trim. The space forward of the engine, which is to be located nearly amidship, will hold about 800 tons of water, while two additional compartments, one on each side of the shaft, leading aft, are calculated to carry 200 tons more. The water-bottom space will have a depth of 42 ins. The specifications call for a capacity of 3,100 gross tons of iron ore on a draft of 16 ft. To handle such immense cargoes eight working hatches will be provided, two of them to be located abaft the engine. The propelling power is to be a three-cylinder ocean-type compound engine. The cylinders are to have a diameter of 22, 36, and 56 ins., respectively, with 42-in. stroke. Two Scotch-type boilers will furnish the necessary steam. The present intention is to make them 14 ft. in diameter and 12 ft. long, but a change from these figures may be determined upon. Because of the central location of the engine and boilers the new steamer will carry two spars only, and a single funnel encased like those on the *Owego* and *Chemung*. In her arrangement forward and aft she will present an appearance similar to the other steamers of the line. Additional deck houses will consist of separate quarters for the chief engineer, a house over the engine for engineers and firemen, and quarters forward of the boiler house for deck hands. Her outfit will embrace all of the latest improvements. Steam will be utilized in every possible direction, and a system of electric lighting introduced throughout every portion of the vessel.

The Pacific Rolling Mills, San Francisco, recently cast successfully the steel stern-post for the new cruiser *San Francisco*. It weighs about 16,000 lbs.

The Red Star Line is building a new steamer to run between Antwerp and New York. This steamer, which was recently launched from the Thomson yard on the Clyde, is named the *Friesland*, and is 450 ft. long, 51 ft. wide, and 38 ft. deep. She will have triple-expansion engines of the latest pattern.

The Jonson Foundry & Machine Company, New York, is building three small steel vessels. One is a tender for the Government light-house service and is 85 ft. long. The second is a boat for the New York Fire Department, 126 ft. in length, and the third a yacht, 60 ft. long. This Company is building a number of engines of the pattern recently described in the Journal. One of them is to be placed in the light-house tender mentioned above, and another has been recently sent to the Mexican Central Railroad.

A new steamer for Chesapeake Bay service was recently launched from the Neafie & Levy yard in Philadelphia. She is 240 ft. long over all, 38 ft. beam, and 24 ft. deep. The engine is a direct acting triple-expansion engine, with cylinders 21 in., 31 in., and 55 in. diameter and 36 in. stroke. Steam will be supplied by two boilers 13 ft. diameter and 14 ft. long, each having three 42-in. corrugated furnaces made by the Continental Iron Works. These boilers will carry a working pressure of 150 lbs. in service.

Electrical Notes.

A new steam launch has recently been completed at Newburg, N. Y., which is 36 ft. long and is run by a motor made by the Electro-Dynamic Company, of Phi adelphia. The electricity is furnished by storage batteries made by the Electrical Accumulator Company, New York.

The Thomson Electric Welding Company has decided to increase its capital stock for the purpose of pushing and extending its business. There are now some 75 of the electric welding machines in use, and their work has been so far very successful.

The Weems Electric Railroad System is just now attracting much attention, and has worked very successfully on the two-mile experimental road which has been built near Baltimore. The Company expects to put up a line five miles in length near New York, also for experimental purposes. On the Baltimore line a speed of about 180 miles an hour is said to be reached.

In May last the East Cleveland Railroad, Cleveland, O., had in operation about 17 cars, with Sprague Electric Motors. During that month these cars made an average of 94 miles a day for the whole number, one car making an average as high as 143 miles a day for the month. The cars were kept constantly at work, there being no reserve, and the work was of the hardest kind.

THE first trip over the Beverly & Danvers Street Railroad was made September 28, and the road is now in regular operation. It extends from Beverly to Danversport, being 3¼ miles in length, and is operated by electricity. The road has a number of sharp curves and grades of 7 per cent., and is very successfully run, a speed as high as 15 miles having been attained on the trial trip. It is run on the storage battery system, the plant being supplied by the Union Electric Car Company of Boston, and the system being the invention of Mr. Stevens. A novel point in the system is that in running down grades where the motor is not required, the force of gravity is utilized to replenish the storage batteries. The cars in use on the road are made by the Ellis Car Company at Amesbury, Mass., and are lighted by electricity. The trial trip was made in 22 minutes over the whole length of the road, and this speed can easily be maintained in practice if required.

AN electric locomotive of somewhat novel design has just been built at the New York Locomotive Works, Rome, N. Y., for W. H. Darling. The storage system is used, the batteries occupying what would be the fire-box in an ordinary engine. The reciprocating movement of the pistons is caused by currents in helical coils wound about the cylinder, the construction being founded upon the principle that an iron plunger will be drawn into a coil of wire through which an electric current is passing.

OWING to the wonderful growth during the last decade of the electrical industry, the Superintendent of the Census has decided to have a special investigation of the subject for the report of the census of 1890. It will be intrusted to Mr. A. R. Foote, of Cincinnati, O., who has been recommended for the position by nearly all the leading firms engaged in the industry and other prominent people generally.

THE new electric light plant at Holden, Mo., is to be run by a 50 H.P. Armington & Sims engine, furnished by the Pond Engineering Company, of St. Louis. The Pond Company have also shipped to Normal, Ill., two of their largest sized feed-pumps and receivers.

Vibration in Buildings.

SOME investigations have lately been made into the question of the vibration in buildings caused by machinery in motion. These were made in connection with the Westinghouse engine, in cases where it was necessary to place engines of this type on upper floors. The theory based upon these investigations is that if the slight motion which every engine has is exactly in time with the natural vibration of the floor beam, each pulsation of the engine will increase the scope of the vibration of the floor, resulting in a most disastrous shaking, while if the pulsations of the engine are in discord with the floor, comparative quiet will exist. As floor beams are usually long, and their time of vibration correspondingly long, it is usually found that a fast-running engine will give less of its vibration to the floor beams than a slow-running one. It is also worthy of note that the vibrations of a fast-running engine are more numerous and less forcible, hence easier resisted by the mass of the floor.

An interesting example of preventing vibration by discord was shown in the case of a Westinghouse 10 H. P. engine which, on an upper story of a silverware manufactory created such a commotion as to rattle the silverware on the shelves 100 ft. distant. A change of 25 revolutions, increasing the speed, entirely stopped the vibrations.

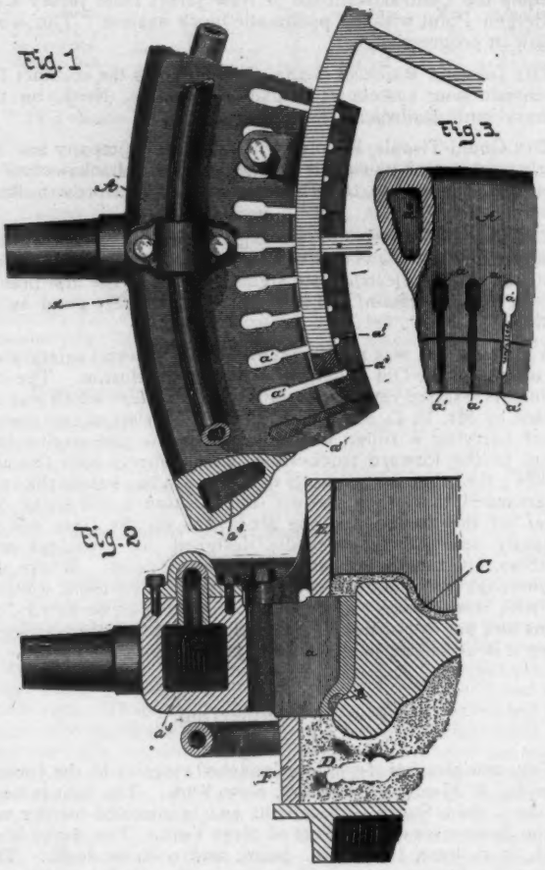
In another case—the factory of Arbuckle Brothers, in Brooklyn—two Westinghouse engines of 125 H. P. each and one of 45 H. P. are located on the fifth floor. These engines were erected on the heavy floor timbers, the floor-boards being cut away and extra timbers being inserted between the joists. Across said timbers were placed oak stringers, which have been seasoning since the war in some unfinished vessels in the Brooklyn Navy Yard. On these the engines were mounted with plain fly-wheels, and experiments were conducted to determine the speed at which it would be best to run. It was found that at 204 revolutions the vibration was at the minimum and was very slight, being as little as that caused by any of the ordinary driven machinery. The speed was therefore fixed at this point, and the wheels then made to give the proper belt speed.

Barr's Contracting Chill.

THE accompanying illustration represents a chill for casting car wheels which belongs to the class known as Contracting Chills, the surfaces of which are formed of a large number of sections separated by narrow radial slits. In order to permit the contraction of the chill, it is usually necessary to make these slits between the sections so wide that the melted metal will run into them, unless they are closed. The object of the present invention is to provide for closing the slits in such a way that the metal will be excluded without preventing the chill from contracting. It therefore consists in combining with the chill a filling of such character as will suit the requirements of the case.

In the accompanying drawings fig. 1 is a top plan view of a portion of a flask and contracting chill for car-wheels with this improvement applied hereto. Fig. 2 is a cross-section of the same on the line $x\,x$, with the wheel therein. Fig. 3 is a plan view, on a larger scale, of a portion of the chill, with the compressible filling therein.

Referring to the drawings, A represents the annular metal chill, having in its outer portion the chamber or passage a^3, to receive a cooling or heating fluid, and having on the inner side the inwardly-projecting segments or chill-blocks a, separated by slits or openings a'. The ends of the segments or chill-blocks stand side by side in a circular row, and are curved on their inner faces to correspond with the circumference of the required wheel, so that they present jointly a circular metal surface adapted to act like an ordinary chill on the tread of the wheel. The metal chill-surface is, however, interrupted or broken by the slits a, as in other contracting chills now in use.



It is to the closure of these slits in a practical manner, so that the chill will present a smooth, unbroken surface of suitable character, and at the same time be free to contract, that the invention is directed. To this end the slits or spaces a are filled with the compound of wheat or rye flour and sand, or the equivalent compounds, taking care to rub the same firmly in place flush with the inner face of the chill. After the filling is in place it is hardened, as before referred to.

It is found that the composition of sand and flour possesses practically the same degree of conductivity as the metal of the chill-blocks, and that therefore the chilling action is practically uniform and the metal of uniform hardness throughout the circumference of the tread. It is also found that the compound permits the chill to contract, that it is not burned out under the influence of molten metal or compressed under the pressure of the metal, so as to leave ridges on the wheel, and that it does not squeeze out under the face of the chill, so as to produce depressions in the wheel.

The invention is covered by patent No. 411,369, issued to Mr. J. N. Barr, of Milwaukee, Wis., under date of September 17 last.

Manufacturing Notes.

THE Philadelphia Scale & Testing Machine Works of Riehle Brothers are very busy on orders for large and small work. Among recent orders is one for a screw-power testing machine of 100,000 lbs. capacity for Andrews Brothers, at Hazelton, O., and one for a wire-testing machine 10,000 lbs. capacity for the Seymour Manufacturing Company at Seymour, Conn.

THE office of Moffett, Hodgkins & Clarke, engineers and contractors, has been removed from Watertown to Syracuse, N. Y. The branch offices in New York and Chicago will be continued as heretofore.

THE Pennsylvania Railroad Company has made contracts for 39,000 tons of steel rails for next year's delivery, 12,000 tons to be furnished by the Cambria Iron Company at Johnstown; 12,000 tons by the Pennsylvania Steel Company at Steelton, Pa.; and 15,000 tons by the Lackawanna Iron & Steel Company at Scranton. The prices range from $28.50 to $30 per ton at mill. The Union Pacific Company has also recently made contracts for 40,000 tons of steel rails for next year, the order being divided among several mills.

AT the Oliver Oil Company's mill at Charlotte, N. C., there is a 65 H. P. Westinghouse engine which has been operated night and day (starting 12 o'clock Sunday night and stopping 12 o'clock Saturday night) for five years, and during that time it has not cost $5 for repairs, and the mill has never stopped a minute on account of the engine.

THE Homestead Steel Works of Carnegie, Phipps & Company recently completed and shipped a lot of steel ties for the Chicago & Western Indiana Railroad.

IN October last the Westinghouse Machine Company, Pittsburgh, sold 30 "Junior" engines, aggregating 935 H.P., 16 standard engines of 645 H.P., and 30 compound engines of 2,510 HP.; a total of 76 engines, aggregating 4,090 H.P.

THE Pond Engineering Company, St. Louis, reports recent sales as follows: For electric lighting, a 50 H.P. Armington & Sims engine to Kansas City; for Joliet, Ill., three 100 H.P. boilers, one 250 H.P. Lane & Bodley Corliss engine, with Hoppes live steam purifier, Lowe heater, pump, injector, etc.; for the State Capitol at Austin, Tex., a 70 H.P. engine and complete plant. For electric railroad work, two Armington & Sims engines of 150 and 70 H.P., with the necessary pumps, heaters, etc., for the Northeast lines, Kansas City; one 125 H.P. engine and complete plant for Laredo, Tex. For other purposes, four 90 H.P. boilers to the cable railroad at San Diego, Cal.; two 150 H.P. boilers for the St. Louis Smelting & Refining Works; one 100 H.P. Lowe heater to Charleston, S. C., for the Palmetto Brewing Company.

AT the works of the Armington & Sims Engine Company, in Providence, a large addition is now under construction. The new building will be filled with machine tools which have already been ordered from the firms of Manning, Maxwell & Moore, New York; Nicholson & Waterman, Providence, and the Pond Machine Tool Company, Plainfield, N. J. A full equipment of traveling cranes and special tools will be provided, and when the addition is completed the works will have a capacity of 150 H.P. of engines per day. A new development at these works is a triple-expansion engine of 250 H.P., now under construction. This engine will have four cylinders arranged in two pairs tandem, the high-pressure and the intermediate cylinders at the rear and two low-pressure cylinders in front. By this arrangement the additional expansion is obtained, while the special features in relation to balancing, etc., of the compound engine, will be retained.

OBITUARY.

JOEL BARLOW MOORHEAD, who died in Philadelphia, October 25, aged 76 years, was born in Dauphin County, Pa., and when only 18 years old took a small contract on the building of the Pennsylvania Canal, and thereafter for a number of years was employed as contractor for railroads, bridges, and other improvements in Kentucky, Indiana, and Pennsylvania. For a short time he was Superintendent of the old State Railroad from Philadelphia to Columbia. He was one of the originators of the Monongahela Improvement, and did most of the work on the locks and dams of that river. His last contract was for the building of the Philadelphia & Erie Railroad. In 1857 he gave up his contracting business, and has since been engaged in the manufacture of iron.

DR. JAMES PRESCOTT JOULE, who died at his residence near Manchester, England, October 10, aged 71 years, was known as one of the most profound and original students of Physics. He was a pupil of the great chemist Dalton, and followed up his investigations besides originating others of his own. He was most widely known from his investigations into heat and electricity, the results of which have been very largely accepted by scientific men all over the world. For a number of years past he has been considered the highest authority on the subjects which he studied.

PERSONALS.

R. A. BRIGGS has resigned his position as Chief Engineer of the Denver & Rio Grande Railroad.

JOHN WEATHERSTON has been appointed Roadmaster of the Detroit Division of the Grand Trunk Railway.

F. HUFFSMITH is now Master Mechanic of the International & Great Northern Railroad, with office at Palestine, Tex.

JOHN F. O'BRIEN has resigned his position as General Manager of the Mexican National Railroad, and will return to the United States.

C. P. MATLOCK has been appointed Resident Engineer of the International & Great Northern Railroad, with headquarters at Palestine, Tex.

CAPTAIN W. T. ROSSELL, U. S. Engineers, has been assigned to duty as Assistant to the Engineer Commissioner of the District of Columbia.

WILLIAM HUNTER has been appointed Engineer of Maintenance of Way of the Central Railroad of Georgia. He was recently on the Atlanta & West Point Railroad.

M. E. SCHMIDT has established an office in Chicago—at No. 1138 Rookery Building—as Engineer and Contractor. He will pay special attention to the introduction of the Abt rack-rail system.

D. PRATT WRIGHT has withdrawn from the old and well-known firm of Whittlesey & Wright, patent solicitors, of Washington. The business will be continued by Mr. G. P. WHITTLESEY.

H. C. POTTER, who resigned the position of General Manager of the Flint & Père Marquette Railroad in August, 1888, has now returned to that road and will hereafter have charge of its business and operations as Vice-President and General Manager.

HENRY S. MARCY has been chosen Vice-President and acting General Manager of the Fitchburg Railroad. The office is a new one, and it is understood that Mr. Marcy is to be the active manager, relieving President Phillips, who will retire on account of his health.

WALTER S. PHELPS, late Master of Machinery of the Ferro-Carril de Guantanamo, Cuba, has resigned that position and has taken charge of the machinery on the large sugar estates of San Miguel, Confluente and San Yldefonso, near Guantanamo, having also charge of the light railroads, locomotives, cars, etc., on these estates for the firm of Bueno & Company.

MARSHALL M. KIRKMAN has been chosen second Vice-President of the Chicago & Northwestern Railroad Company. He will continue to have charge of the accounting department of that company, which has been under his control for so long. Mr. Kirkman has a very high reputation as a railroad accountant, and his books on the subject are standard authorities.

NATHAN GUILFORD has been recommended by the Committee of the Trunk Line Association for the position of Trunk Line Commissioner in place of General Albert Fink. Mr. Guilford has had a wide experience on the Baltimore & Ohio and other railroads, and was for some time Mr. Fink's Assistant. The recommendation of the Committee has not yet been acted upon by the Association.

FREDERICK E. SAWARD, Editor of the *Coal Trade Journal*, has been appointed a member of the General Committee of the International Exposition of 1892 in New York, as a representative of the Coal Trade. Mr. Saward is eminently qualified for the position, not only as a representative of a very important industry, which no one knows more thoroughly than he, but also as a man of great energy and activity, who is certain to be a valuable member of the Committee.

PROCEEDINGS OF SOCIETIES.

Railway Telegraph Superintendents' Association.—The eighth annual meeting was held in Washington, October 16 and 17, with a large attendance. The following officers were elected: President, C. A. Darlton; Vice-President, George T. Williams; Secretary and Treasurer, P. W. Drew. Niagara Falls was chosen as the place for the next meeting.

The time on the first day was mostly taken up by an elaborate paper on Electric Lighting of Trains, by Mr. Charles Selden, of the Baltimore & Ohio, and by discussion on this paper.

On the second day there were reports and discussions on Cipher Codes, on Night Messages, on the Train Telegraph and several other subjects. A discussion on the Block System was postponed until the next meeting.

American Street Railroad Association.—The eighth annual meeting began in Minneapolis, Minn., October 16, with a large attendance. Eight additional companies were admitted to membership. The President delivered the opening address, after which the Executive Committee presented a long and elaborate report. The Treasurer presented a report showing that the Association was in good financial condition. Reports were presented by the Committee on Mutual Insurance and also by the Committee on Employés' Relief Associations, the latter giving rise to considerable discussion.

The evening session was devoted to a report on Electricity as a Motive Power, the main point in the report being a discussion of the financial results obtained on electric railroads. This called out a very long discussion and many differences of opinion.

The second day a report was presented on Motors for Street Railroads, which was a long and careful discussion of the experience had with motors other than animal and electric. The conclusion reached was that, while the cable-road is the best plan yet adopted where the traffic is large, there is a broad field still open for the adoption and use of some practical and economical motor for railroads whose business is not large enough to warrant the expense of a cable plant.

A report was presented on the Care of Horses which was thoroughly discussed, and another report on Public Sentiment toward Corporations.

Buffalo was chosen as the place for the next Convention, and the following officers were chosen for the ensuing year: President, Thomas Lowry; Vice-Presidents, C. Densmore Wyman, J. C. Schaffer, and Robert McCulloch; Secretary and Treasurer, William J. Richardson; Executive Committee, George B. Kerper, George W. Kiely, Raphael Semmes, Frank H. Monks, and F. M. Eppley. The Convention was closed in the evening by the annual banquet.

Master Car-Builders' Association.—The following is the list of subjects upon which reports are to be presented to the Convention of this Association next year, with the names of the Committees to whom has been assigned the duty of preparing the reports.

1. Journal-box, Bearing, and Lid for 60,000-lbs. Cars, and Lid for old Standard Journal-box: Committee, John S. Lentz, F. D. Casanave, R. McKenna, J. N. Lauder, A. A. Jackson.
2. Metal for Brake Shoes: G. W. Rhodes, B. K. Verbryck, E. B. Wall.
3. Lettering Freight Cars: E. W. Grieves, G. W. Demarest, R. D. Wade.
4. Steam-Heating and Ventilation of Passenger Cars: J. N. Barr, T. A. Bissell, J. W. Marden, J. C. Barber, W. H. Lewis.
5. Steel Plate and Malleable Iron in Car Construction: William Forsyth, John MacKenzie, E. D. Bronner.
6. Code of Rules for Interchange of Passenger Equipment Cars: C. A. Schroyer, R. Kells, J. H. Rankin, J. B. Henney, T. Sutherland.
7. Loading Bark and Logs on Cars: R. C. Blackall, William McWood, F. D. Adams.
8. On Expediency of a Change in Standard Height of Drawbars in Passenger Equipment Cars: E. D. Nelson, John Kirby, H. Middleton.
9. On Place of Meeting in 1890: R. D. Wade, W. H. Day, G. W. Demarest.

Northwest Railroad Club.—At the meeting in St. Paul, November 9, Mr. Griffin read a paper on Car-Wheels, discussing the comparative merits of the common chill and the contracting chill for making cast-iron wheels. This paper called out a long discussion between Mr. Griffin, Mr. J. N. Barr, and others.

Central Railway Club.—A regular meeting of this Club was held in Buffalo, October 23, which was mainly devoted to discussion of proposed amendments to the Master Car-Builders' Rules of Interchange. A committee was appointed to suggest changes which may be advisable.

The Committee appointed to report on Coal Consumption and Economical Appliances asked for further time, and was given until the January meeting.

Western Railroad Club.—At the regular meeting in Chicago, November 19, the first subject was Compound Locomotives. This was opened by a paper read by E. W. M. Hewes, in which he described the methods employed by him on the Indian State Railroads, in changing simple to compound locomotives.

The second subject was the Best Metal for Brake-Shoes, which was opened by an account given by Mr. E. C. Case of experiments made by him on the St. Louis & Hannibal Railroad. Both papers were discussed by members present.

American Society of Mechanical Engineers.—The programme for the fall meeting of this Society, which began in New York, November 18, was as follows:

On Monday evening the meeting was opened by a reception at the rooms of the Society, No. 64 Madison Avenue. This was intended not only as an opening of the Convention, but as a sort of house-warming for the new rooms and library.

On Tuesday the programme included sessions for general business and for the reading of papers in the morning and afternoon, and in the evening the annual subscription dinner of the Society.

Wednesday was devoted to excursions to various points of interest. In the evening a reception was tendered to members by the Engineers' Club.

On Thursday there were morning and afternoon sessions for the reading of papers and discussion, and in the evening members visited the American Institute Fair.

On Friday there was a session, in the course of which a paper on the Performance of the Double-screw Ferry-boat *Bergen*, of the Hoboken Ferry, by Colonel E. A. Stevens and Professor J. E. Denton, was read.

Among the papers announced for this meeting were the President's Address, by Henry R. Towne; Philosophy of Compound Engines, by Professor R. H. Thurston; Cost of Lubricating Car-Journals, by L. S. Randolph; Rolling Steel Rails, by Dr. R. Nicholson; Indicator for Compound Engines, by F. W. Parsons; Transmission of Force in the Steam-Engine, by D. S. Jacobus; Cost of Steam and Water Power, by C. T. Main; and a number of others of interest.

American Society of Civil Engineers.—At the regular meeting in New York, November, 6, a committee was appointed to respond properly to the address received from the Institution of Civil Engineers in relation to the visit of American engineers to England last summer. The matter of arranging jointly with the Mining and Mechanical Engineers for entertaining the British Iron & Steel Association next year was referred to the Board.

The Committee on Revision of the Constitution submitted a report noting the progress which had been made in its work. The work was accepted, and the Committee continued to report at the annual meeting in January.

The tellers announced the following elections:

Members: B. W. De Courcy, Port Townsend, Wash.; John Q. Jamieson, Portland, Ore.; William W. Kenly, Wilmington, Del.

Juniors: William F. Behrens, Albuquerque, N. M.; M. C. Hamilton, Hartford, Conn.; George W. Sherwood, Bethlehem, Pa.

Mr. C. E. Emery then read a paper on a Visit to the Forth Bridge, and Reminiscences of the Trip to Europe, which was discussed by members present.

Engineers' Club of Philadelphia.—At the regular meeting, October 19, the Secretary presented, for Mr. Conway B. Hunt, a very complete description of Repairing a Bridge Pier Foundation. These repairs were made to what is known as Pier No. 1 of the Aqueduct Bridge over the Potomac River. The rock bottom of the river is from 25 ft. to 35 ft. below low tide. After an extraordinary freshet a settlement was discovered, and investigation showed that a cavity had been scoured under the pier, extending the full length of the pier and across its upstream end. This cavity was about 4 ft. high and extended about 6 ft. back under the pier. The Author then gives a very

full description of the manner in which this pier was constructed, from which it appears that all of the masonry had not been extended to the rock. After the first settlement was observed it was found to continue, and repairs were at once begun. These were made by lowering concrete in loosely filled bags, which were packed in the irregular cavity by divers, and by lowering concrete in tubes, which were tripped and the material pushed with hoes and special tools into all the remaining portions of the cavity, until it was completely filled with a substantially solid mass of concrete. The outer surface of the pile of bags was finished with loose concrete. The method of preparing the concrete and doing the work is then described. The repairs occupied about 11 working days, and about 110 cubic yards of concrete were used. The total cost of the work was $3,112 ($28.28 per cubic yard); this does not include $1,394 additional spent for rip-rap. There was some discussion of kindred subjects by Messrs. E. H. Brown, Howard Murphy, and Professor L. M. Haupt.

At the regular meeting in Philadelphia, November 2, the Secretary presented, for Mr. Edward Hurst Brown, a description of Driving Piles by Water.

There was some discussion by Mr. Frederic Graff and Professor L. M. Haupt.

Mr. P. F. Brendlinger presented a very full and illustrated description of the Grout Pump and Methods of Grouting the New York Aqueduct.

There was an extended general discussion of matters concerning this engineering structure.

Boston Society of Civil Engineers.—At the regular meeting, October 16, F. W. Dean, B. R. Felton, and George J. Leland were elected members. The Committee to confer with the American Society of Civil Engineers reported progress.

The rest of the meeting was devoted to the presentation by members of their notes and experiences gathered during the trip of the American Engineers to Europe last summer.

Engineers' Society of Western Pennsylvania.—At the regular October meeting, James O. Handy was elected a member. A committee was appointed to prepare a suitable memorial of the late Captain William R. Jones.

Mr. I. S. McGiehan read a paper on the Standard Metal Tie, giving an account of experience with metal ties in Europe and this country. The paper was discussed by Messrs. Hunt, Hibbard, Swensson, Davison, Thaw, and Verner.

Michigan Engineering Society.—The officers of this Society, elected by letter-ballot for the ensuing year, are as follows: President, R. C. Carpenter, Lansing; Vice-President, J. H. Forster, Meridian; Secretary, F. Hodgman, Climax; Directors, George E. Steele, M. E. Cooley, Charles E. Greene.

The annual meeting for 1890 will be held in Detroit in the third week in January. The Society now numbers 135 members, including the most prominent civil, mechanical, and mining engineers in the State. It is incorporated under a special act of the Legislature and issues each year a valuable annual.

Engineers' Club of Cincinnati.—The fifteenth regular meeting of the Club was held October 24, with 10 members present.

A committee of three was appointed to confer with the committee of the American Society of Civil Engineers in relation to the proposed uniting of the various Engineering Societies of the country.

In the absence of any prepared paper for the evening the members discussed the accident which occurred recently at the inclined plane extending to one of the hill-tops in Cincinnati, by which several lives were lost. The proper connection of cable to car, the use and reliability of various clutch and brake devices, etc., were discussed at some length and proved interesting and instructive.

Engineers' Club of St. Louis.—At the regular meeting in St. Louis, October 23, John Dean was elected a member. The Secretary read a letter from the Chairman of the Board of Managers of the Association of Engineering Societies, proposing a meeting of the Board to consider the question of proposed affiliation with the American Society of Civil Engineers.

Mr. H. A. Wheeler then presented some notes regarding the recent European trip of the American engineers. Some 300 members of the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the Institute of Mining Engineers took part. Mr. Wheeler gave full particulars of the trip.

The special order of the day was the securing a permanent place of meeting. After discussion a committee was appointed to consider the subject.

Mr. Johnson exhibited a test piece of iron, which had been welded by the electrical process at the Exposition.

At the regular meeting in St. Louis, November 6, the Committee on Location recommended that the Club rent rooms in the Laclede Building. The report was approved, and the Executive Committee authorized to lease a room and furnish it. Mr. Winthrop Bartlett read a paper on the Olive Street Cable Railroad. The total length of this road is 9.6 miles, the conduit is 39 in. deep; the Johnson rail, weighing 65 lbs. to the yard, is used. The percentage of power required to drive the cable alone is low for a road of this class The fluctuations in the power required are very great, as was shown by an indicator card in which the power varied from 136 to 609 H.P. within one minute. The paper was discussed by members present.

Western Society of Engineers.—At the regular meeting in Chicago, October 2, Mr. Cope Whitehouse read a long and interesting paper on Irrigation in Egypt. Mr. Whitehouse also gave his theory of the Pyramids, which he considered as monoliths cut down from conical hills originally standing on the spot, and then reveted with the rock obtained in the process of cutting.

Engineers' Club of Kansas City.—At the regular meeting, October 7, a paper presented by Messrs. Waddell and Jenkins described tests made in St. Louis on specimens of Phœnix Stone for freezing, absorption, fire, abrasion, crushing, specific gravity, together with a microscopic analysis, the results on the whole indicating a very superior stone.

The Club is indebted to the Phœnix Stone Company for samples of their stone, together with a handsome table for the Club.

At the regular meeting in Kansas City, November 4, John R. Braidwood and Robert M. Sheridan were elected members and Thomas H. Ashburner an associate member. Charles H. Hastings was chosen Librarian in place of F. Allen, resigned.

The paper on Building Stone, read October 7, was discussed. Short papers on Sewer Ventilation, by F. E. Sickels, and on Sewerage Disposal, by K. Allen, were read and discussed.

Papers by Professor L. M. Haupt and John Willett, on an Outer Harbor off Padre Island, Tex., were also read and discussed. The plan for the harbor includes the building of an iron pier out into the Gulf, 4,500 ft. from shore.

Montana Society of Civil Engineers.—At the October meeting in Helena, Mont., a report was received from the Committee on Irrigation. The Committee on Public Land Surveys was requested to report at the next meeting. The Committee on Relations with the American Society of Civil Engineers recommended that action be deferred, and a special Committee appointed to confer with the American Society and with the local engineering societies. This action was taken.

Colonel De Lacy read a paper on the History of Public Land Surveys, and suggests the abolition of the present system, and the adoption of an entirely new system with a special call of land surveyors.

Franklin Institute.—The programme for the month of December includes lectures on the following subjects: December 2: Chemistry, by Professor C. H. Henderson; December 6: The Optical Lantern as a Means of Demonstration, by F. E. Ives; December 9: Emery-Wheels, by Dunkin Paret; December 13: Duty of Pumping Engines, by William M. Barr; December 16: Electricity, by Ralph W. Pope; December 20: Cost of a Steam Horse-Power, by Thomas Pray.

New York Railroad Club.—The first regular meeting of the season was held October 21. The subject for discussion was Journal Bearings. It was opened by Mr. George R. Menedy, who read a long paper, giving the history of many experiments and trials, and an account of tests made of the roller bearings invented by him, which showed a very excellent result. The paper was discussed by members present.

NOTES AND NEWS.

Petroleum in Burmah.—Some surveys of the petroleum deposits in Burmah have been made by the Indian Geological Survey, and it is stated that the working of these deposits has so far been carried on in a very imperfect way and without system. The deepest wells used are from 250 to 300 ft., and these leave untouched fully 100 ft. of the oil-bearing sandstone. When proper methods and sufficient capital are employed, there is little doubt that these oil deposits can be profitably worked and will yield largely, and the officers of the survey believe that from them the demand in India can be fully supplied, with probably a surplus for export to other eastern countries.

German Canals and Water-ways.—The Rhine, on a navigable length of 435 miles, has a yearly traffic of 5,500 vessels averaging 200 tons each, ranging from 386 vessels of 50 tons to 14 of 1,300 tons. On the Danube the number of vessels is about 800, ranging from 75 to 525 tons, average 200 tons. On the Elbe the number is 9,400, average tonnage, 106. From Vienna there may be reckoned three great water-ways: (1) The Danube; (2) the Danube-Oder Canal, giving communication with Prussia; and (3) the projected connection from this canal to the Elbe.

On the Danube the westward limit of navigation is at present Regensburg, 281 miles from Vienna, although it is probable that the channel as far as Ulm, 131 miles further, is well suited for chain-traction. Connection could be made with the Rhine in either of two directions: firstly, from Dillingen, about 31 miles below Ulm, *viâ* Königsbronn (1,640 ft. above sea-level) to the Neckar, and from Cannstadt to Mannheim; and secondly, by Kehlheim, Nürnberg and Bamberg (1,375 ft.) to the Main, and thence from Frankfort to Mainz.

The canalization of the Main from Frankfort to Mainz has been attended by the most noteworthy commercial results, in spite of the unfavorable dry season following the completion of the work. The saving of freight on goods to and from Frankfort has amounted to $185,000, and to other places between the terminal points $98,000. The saving on coal freight alone has paid 6 per cent. on the Frankfort Harbor Works.

On the 46.5 miles length of the Rhine between the Main and the Neckar there are the following river ports and commercial landing places:

Port.	Trade.	Total Length of Landing Places.	Average Tonnage per Mile.
	Tons.	Miles.	
Frankfort	654 000	4.4	148,500
Gustavsburg	427 000	1.0	402,500
Mainz	202,000	9.9	21,000
Mannheim	1,796,000	12.4	145,000
Ludwigshafen	647 000	1.9	348,000
Total	3 726,000	29.6	125 870

The traffic of this district is capable of immense development. A canal is now projected from Strasburg to Ludwigshafen, which would make Strasburg a western central point of European inland navigation, as Vienna must be the central point for Eastern Europe.—*Wochenschrift des Oesterreichischen Ingenieurs Vereines.*

The Casalmaggiore Bridge.—This bridge consists of 17 spans, of which those at each end are 180 ft. and the other 15 are 213 ft. each, the total length between the abutments being 3,560 ft. The piers and abutments were founded by means of compressed air at depths varying from 65 to 85 ft.

The bridge is for a single track, the load being on the bottom chord. It is formed of two parallel continuous lattice girders fixed upon the eighth pier, and supported on rollers on the other piers and abutments. The river, when not in flood, is 1,312 ft. wide, and a temporary bridge of timber was built over this width for the carriage of materials. Near one of the abutments shops were erected for the engines, air-compressors, pumps, dynamos, repairs, smithies, stores, and offices. After the first 10 supports had been built, these shops and their contents were transferred to the other side of the river. The air-compressors were driven by two semi-fixed engines of 35 nominal H.-P. each, and one of 10 H.-P., the latter being used for shallow depths.

The whole of the compressed-air foundations were completed in 14 months, during two of which work was suspended on account of the cold. The material excavated, which was almost entirely of a sandy nature, was thrown by the workmen into a chest about 1 ft. 8 in. square, and 2 ft. 8 in. high, into which water was pumped through a pipe so as to mix with the sand. The mixture was then forced out through another pipe, in an almost continuous stream, by the pressure of the compressed air in the chamber. By this means a volume of about 130 cubic yards, in the proportion of one-third of sand and two-thirds of water, was forced out in 24 hours. The working chambers were lighted by electric lamps continuously, and during the night the temporary bridge and the whole of the shops were also lighted, there being in all 50 Edison lamps of 6-candle power each, driven by a 4 H.-P. (nominal) portable engine. The total depth of foundation amounted to 1,312 ft., and was executed in 383 working days of 24 hours. There was no considerable flood in the river during this period.

The calculations for expansion and contraction were based on the assumption that the temperature would range from 14° to 104° Fahrenheit, and that the difference in temperature between the top and bottom flanges, owing to the top being in the sun and the bottom in shade, might amount to 22°. This difference might be disregarded in a single-span bridge, but in the case of eight or nine continuous spans it must be considered, owing to the fact that it will have a tendency to throw the uprights out of the vertical, and strains will be brought upon the flanges in resisting this.

This bridge carries the Parma-Brescia Railroad over the River Po, at Casalmaggiore, Italy.

Haulage Resistance in Channels of Limited Dimensions.—Where the channel is sufficiently deep and broad, it is, as a general rule, advisable to convey goods in as few vessels as possible, as the number of vessels among which a given cargo is distributed materially affects the extent of the dead load, and increases the resistance. The Author remarks, however, that this does not always hold good with water-ways of more limited depth and width, where the relation between the sectional areas of the channel and of the boat has to be taken more closely into account.

For instance, a tug traveling at the rate of five miles an hour will, with certain dimensions of channel, haul a load of 205 tons on one vessel, or of 260 tons if the cargo is distributed over two boats. The author discusses at length the varying conditions of velocity and resistance, the results being briefly expressed below. In these tables T = depth of water in feet, F = sectional area of water-way in square feet, n = sectional area of water-way ÷ submerged sectional area of vessel, and N = total resistance.

In the case of the 205-ton load on one vessel, with draft area of 74.8 sq. ft.:

T.		F.	n.	N.
Ft.	Ins.			
4	0	430	5.76	62
4	3	754	10.07	35
4	6½	1 015	14.40	30
4	8	1,400	18.70	28
4	9½	1,720	23.02	27

With 260 tons distributed over two vessels, draft area = 54.7 sq. ft.:

T.		F.	n.	N.
Ft.	Ins.			
4	0	430	7.87	50
4	3	754	13.78	37
4	6½	1,015	19.68	34
4	8	1,400	25 59	32
4	9½	1,720	31.50	31

It will be seen that with the smaller channels the resistance is less in the case of the two coupled boats than in the one larger vessel, but that, as the water-way increases, this relation is reversed. It will, therefore, be found that at one point—that at which F = 645 sq. ft., and N = 39, with a depth of 4 ft., the same power will haul either 205 tons on one boat or 260 tons on two smaller boats, at the rate, in either case, of 5 miles per hour. Where the proportion n (see Table 1) = 5.76, the resistance is 2.7 times greater than where the water-way is practically unlimited, while where n = 31.5 (see Table 2) it is only 1.12 times greater.—*Zeitschrift des Vereines Deutscher Ingenieure.*

The First Iron Works in America.—An interesting article by Mr. Nathan M. Hawks in the *Magazine of American History* for November gives an account of what is claimed to be the first iron works in America. A company or association was formed in Lynn, Mass., in 1642, to work the iron ore which was found on the banks of the Saugus River, and this company established a village called Hammersmith near the place where the ore was found. In 1649 it was stated that the works were making about seven tons a week and they had then been running for six years, active operations having been begun in 1643. A charter, with exclusive privileges of making iron in the Colony, was granted by the General Court in 1645. These iron works continued to flourish until about 1688 or 1690, when they were discontinued, for what reason does not seem to be exactly known, although litigation with the landowners over damages to their property had apparently something to do with it, and doubtless the discovery elsewhere of iron ore, which could be better and more cheaply worked, had also its influence. The works embraced a blast furnace or foundry, as it was called, and a refining forge, and do not seem ever to have exceeded the product mentioned, about seven tons a week.

A New Ship Railroad.—A ship railroad devised by William Smith, of Aberdeen, Scotland, on what he calls the flexible-car system, was recently described by him to the Liverpool Chamber of Commerce. He said that the object of his invention was: 1. To keep a ship of any dimensions water-borne upon the car, with a uniform pressure over the skin of the ship upon a film of water forming a small percentage of its weight. 2. To make the car sufficiently flexible to admit of the usual railroad gradients. 3. To make the wheel-base sufficiently flexible laterally to admit of curves, switches, crossings, and passing places on the multiple ship railroad. These results, he said, had been successfully attained by the contrivances of hydraulic cushions, sectional cars, with adjustable sides, and the compound bogies, or trucks.

Comparing ship railroads with ship canals, the average cost per mile of which was $1,000,000, through the most favorable description of country, he said the flexible-car ship railroad would only cost $300,000 per mile.

A ship railroad on the rigid-car system would, he said, cost $400,000, and would not be nearly so efficient. A railroad on this latter system is in course of construction at Chignecto, N. S. If it proves a success there is obviously a great future before the ship railroad on one plan or the other. The whole thing is so much out of the range of practical experience, that nothing will settle the question of its practicability, except such an experiment as that now in preparation at Chignecto.—*Nautical Magazine.*

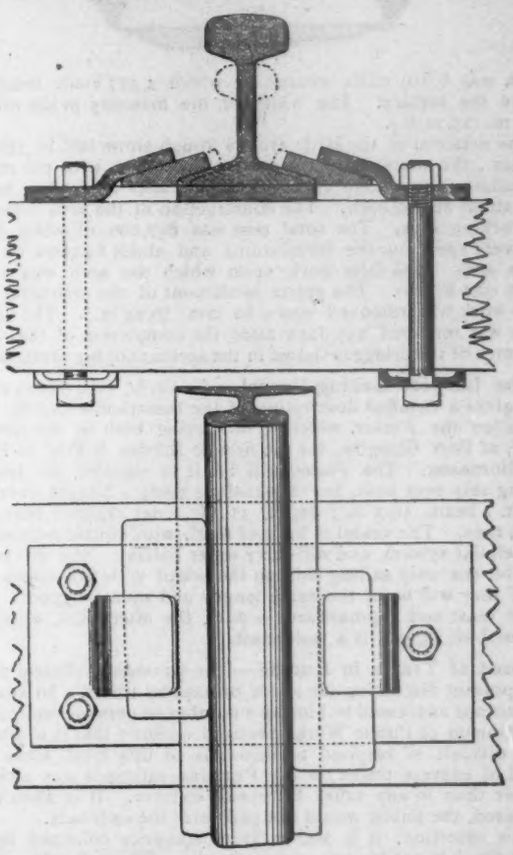
Electric Lighting of Trains.—At the recent meeting of the Telegraph Superintendents' Association, Mr. Charles Selden, of the Baltimore & Ohio, read an interesting paper on the Electric Lighting of Trains. After giving a short sketch of what had been done, he said that there were three systems of lighting cars: By joint use of a dynamo and storage battery; by means of a dynamo and direct current; and by charged storage batteries. The first system is in use by the Pullman Company upon the limited New York-Chicago trains; on the vestibule trains of the Atchison, Topeka & Santa Fé, and some others. In this system a Brotherhood engine directly connected with the dynamo is placed in the baggage car, the engines being supplied with steam from the locomotive boiler. Each car carries in a box under the bottom of the car 32 cells of storage battery, and under the system of distribution this storage battery is partly in use at all times, furnishing, when the dynamo is running, about 30 per cent. of the power given to the lamps, and, when the dynamo is not running, all the power. The weight of the storage battery and box is about 1,300 lbs. per car. During the day or at other times when the lines are in use the dynamo is run long enough to charge these batteries, so that it is not necessary to remove them from under the car for a considerable time. This system requires the service of a special attendant, who is experienced in electric lighting, and who, in the case of the Pullman train, is paid $90 per month.

The system of lighting direct from a dynamo, without the use of a storage battery, is not now in use, but, in the opinion of the writer, could be advantageously employed, saving the expense of the batteries. The objection is that, in case of any failure either in the engine, dynamo, or connections, the lights would go out; but this he does not think a serious one.

The third system of lighting, by storage batteries entirely, the batteries being charged at the terminus, is in use on the Pennsylvania Railroad, the Boston & Albany, and some others. The expense of this system is not stated.

The paper gives the following as the cost of a plant for a single train, approximately: Baggage car, including engine and dynamo, $1,840; mail car, $427; two day-coaches, $462 each; sleeping car, $504; dining or parlor car, $487; total, $4,182. The cost per year for a train consisting of a baggage, two ordinary cars, and two sleeping cars would be: Depreciation of plant, $770; interest, $208; service of attendant, $1,080; total, $2,058. This system makes no allowance for the cost of the steam furnished from the locomotive. On the basis of 365 days of 10 hours each, the cost per day would be $5.64 for a train, or 6.6 cents per lamp per day. These figures have been very carefully prepared, and it is believed that full allowance has been made for depreciation. The cost per day for a sleeping car would be $1.72; for an ordinary car, $0.92; and for a baggage car, $0.33. On this basis, and from the figures given above, the cost for an ordinary train can readily be estimated.

Sandberg's Base-Plate for Rails.—Mr. Sandberg's new heavy rail as last designed has, in addition to a wider head, been modified by adopting a narrow flange with a view to using steel base-plates with it. The width of the flange or foot varies from 3½ in. for a 50 lbs. section up to 5 in. for a 100-lbs. section.



With an 8-in. tie this would give a bearing of from 28 to 40 sq. in. on the tie; but owing to the way in which ties are often cut, this bearing is sometimes considerably reduced. In order to give as much bearing on the tie as is obtained by the double-headed rails and iron chairs used on so many English railroads, and thus to meet the view of English engineers, Mr. Sandberg has designed a steel base-plate 7 × 16 in. in size and ½ in. thick, giving a bearing surface of 112 sq. in. on the tie, offering the same method of fastening—by bolts or wood-screws—as a chair. These are the general dimensions, which, of course, may be modified according to circumstances. Clips are made in the base-plate, as shown in the accompanying illustration, and the rail is fixed to the base-plate by steel keys driven in between these clips and the flange as shown. In this way the tie can be removed without removing the rail, the same as with a chair. Where it is deemed best to set the rail at an angle, as is done on many European roads, it can be obtained in several ways: by cutting the top of the tie, by bending the plate, or by rolling the base-plate of varying thickness. The rail-joint would be suspended by angle fish-plates, which offer sufficient bearing surface on the joint ties, so that the base-plates would only be needed on the other ties. The same plate may be used for rails with flanges from 4 in. to 5 in. wide, the only change necessary being a different size of key. The plate, as designed by Mr. Sandberg, is only 16 lbs. in weight.

The Lavaur Bridge.—The new railroad from St. Sulpice to Castres, France, crosses the Agout River near Lavaur bya masonry arch of 61.50 m. (201.72 ft.) span and 27.50 m. (90.20 ft.) in height. The use of so large a span in this place was warranted by the presence of a very solid foundation ; in fact, there stands close by, and resting upon substantially the same ground, a very handsome masonry arch built in the eighteenth century, and having a span of 48.73 m. (159.83 ft.) and height of 19.49 m. (63.93 ft.). Upon the flank of the large arch are several smaller arches of 450 m. (14.76 ft.) opening. These smaller arches are backed by two heavy piers of stone, which are connected with the abutments on either side by two arches of 8 m. (26.24 ft) opening. The total length of the viaduct is 123.50 m. (404.88 ft.). The actual amount of masonry, including the foundations, was 6,619 cubic metres, of which 4,517 cubic meters is above the surface. The width of the masonry in the arch is 4.80 m. (15.74 ft.).

The material of the large arch is rough stone laid in cement mortar ; the piers and upper work are faced with cut stone. In building the bridge two very large cranes were used, which cost about $2,700 each. The construction of the arch occupied 82 working days. The total cost was $97,000, of which $16,200 were spent on the foundations and about $40,000 on the large arch. The false-work, upon which the arch was built, alone cost $7,600. The entire settlement of the arch after the false-work was removed was 0.62 mm. (0.24 in.). The false-work was removed 135 days after the completion of the arch. A sketch of the bridge is shown in the accompanying illustration.

The Largest Sailing Vessel.—*Le Yacht*, in a recent number, gives a detailed description of the remarkable sailing vessel called the *France*, which is now being built in the Russell Yard, at Port Glasgow, for the firm of Bordes & Fils, of Paris and Bordeaux. The *France* will be, it is claimed, the largest sailing ship ever built, her dimensions being : Length over all, 376 ft. ; beam, 49.3 ft. ; depth, 33.7 ft. ; net register tonnage, 3,600 tons. The vessel is built of steel, with double bottom on the cellular system, and will carry water ballast. She will probably be the only sailing ship on the ocean with five masts ; of these four will be of the same length and square-rigged. The lower mast and topmast are in one ; the after-mast, which is fore-and-aft rigged, is a pole-mast.

Speed of Trains in Europe.—The German technical press is at present discussing the speed of express trains. In answer to petitions addressed to him by a number of persons interested, the Minister of Public Works declared recently that it would be very difficult to respond to demands of this kind, since the speed of express trains on the Prussian railroads was already greater than in any other European country. If it should be increased, the public would not patronize the railroads.

This assertion, it is shown from statistics collected by *Le Genie Civil*, is not by any means correct. The following table shows the average speed of fast trains in different European countries, and shows that Germany does not by any means occupy the first rank :

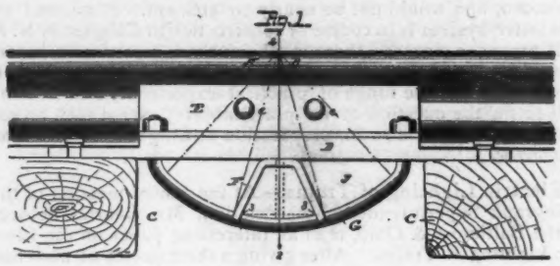
Country.	Speed per hour in miles. Including stops.	Without stops.
Great Britain	41.7	44.6
France	32.8	36.2
Holland	32.5	35.0
Belgium	31.8	33.5
North Germany	31.8	34.3
South Germany	31.2	33.0
Austria-Hungary	30.0	32.0
Italy	29.5	31.8
Russia	29.0	31.7

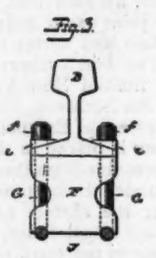
The inferiority of Germany in this point of view finds a marked expression, if we compare the speed of the great Oriental Express, which runs between Paris and Constantinople, passing over the railroads of a number of European countries, including Germany. This train is the fastest long distance express train run in Europe, and from the time-table the average speed in the different countries is as follows : In France, 40.5 miles per hour ; in Germany the speed varies in different sections, being in Alsace-Lorraine, 32.5 miles ; in Baden, 35.5 miles ; in Würtemberg, 30 miles ; in Bavaria, 33.7 miles. In Austria the average speed is 33.5 miles ; in Hungary, 34 miles ; and in Roumania, 32 miles. This comparison, it will be seen, is not altogether to the advantage of the German lines.

In this connection some comparison may be made of the passenger tariffs in different countries. From this it appears that the lowest charges, both for first and second-class passages, are in Belgium, Holland coming next, then Germany, then France, then Austria-Hungary. England and Italy charge the same fare for first-class passages, but the English second-class is considerably lower than the Italian. The highest fares in Europe are in Russia. Third and fourth-class fares are not included in this system, as those classes of passengers are not generally carried on the fast express trains.

Rail-joint Support.—The accompanying illustration shows a new spring truss support for rail-joints. Fig. 1 is a side view of the device ; fig. 2 a section on the line 22, fig. 1 ; fig. 3 is a section showing a modified form. In these figures *A B* are the rails ; *C C* the adjoining ties, and *J* the spring truss. This consists, in addition to the rails or base-plate, of two members *F* and *G*, the latter being the spring member and consisting of one or more curved steel blades or bars suspended below the rails and supporting the other member, *F*, which consists of a plate of wrought iron or steel of an inverted Λ shape, the limbs resting on the spring member and the apex below the meeting ends of the rails.

The members of the truss may be in direct contact or connection with the rails themselves, as shown in fig. 3, which represents a construction in which each flange of each rail is perforated for the passage of one of the ends of one of the rods constituting the spring member, each end of each rod being threaded to receive a nut *f*, which bears upon a wedge-like washer *i*, of such a shape as to afford a level bearing for the nut, and the apex of the rigid member *F* is in direct contact with the under sides of the rails. Instead of this construction shown in fig. 3, the other two members of the truss may be indirectly connected with the rails through the medium of a base-plate *D*, suitably bolted or otherwise secured to the rails, and perforated or otherwise formed for the attachment of the spring member of the





truss, and channeled to receive the rails, and resting with its lower face below the meeting ends of the rails upon the member *F*.

As shown in figs. 1 and 2, angle-plates *E E* are used as means of connection between the base-plate and the rails, each angle-plate being secured to the base-plate by bolts, or by means of the rods constituting the spring member of the truss, as shown, and being also secured to the sides of the rails by means of a transverse bolt or bolts *e*.

In the construction shown in figs. 1 and 2 the base-plate is spiked to the ties, and there are two cross-bolts *e*, both passing through elongated openings in the angle-plates, so as to permit expansion and contraction of the rails without strains upon any portions of the truss.

The spring member is composed of metal having a slight elasticity ; the curved form is not essential. This invention is covered by Patent No. 413,347, issued under date of October 22 last to the Long Spring Joint Truss Company of Chicago, assignor of Richard Long, now deceased.